Compressed Air Magazine

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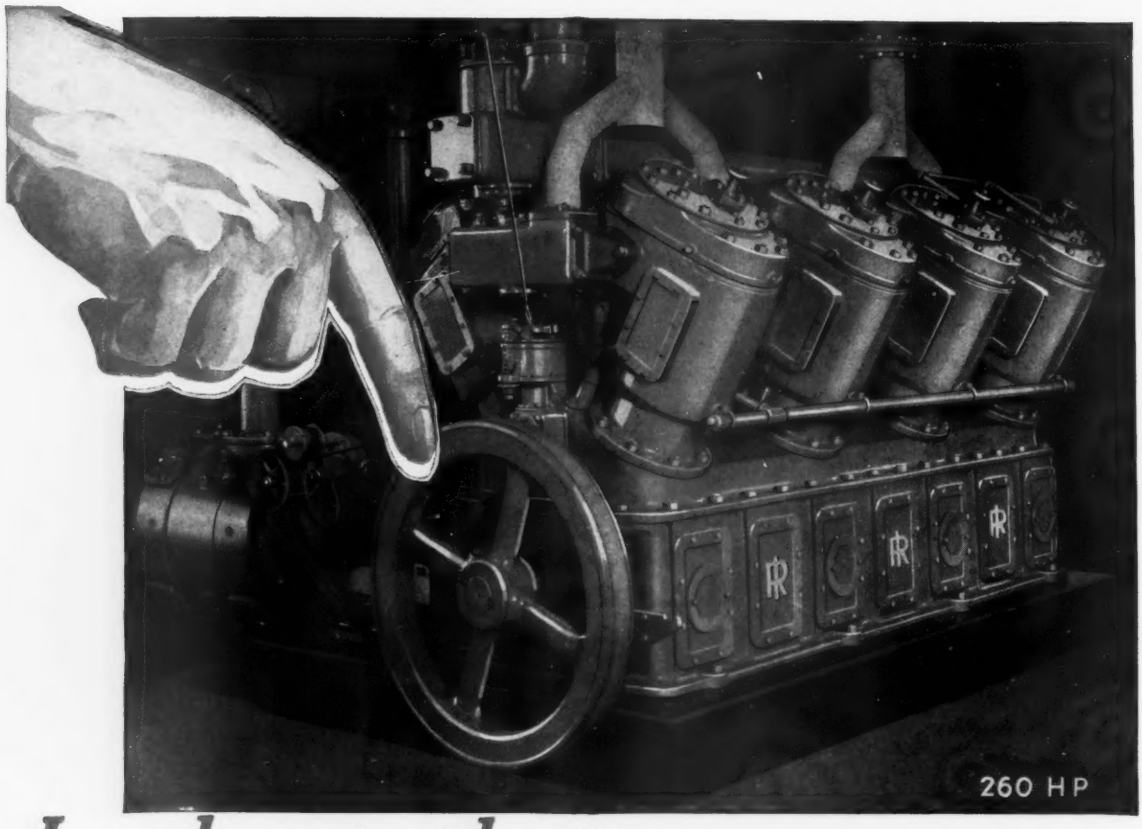

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As It Seems To Us

LOOKING UNDERGROUND

IT IS a far cry from the dowser, who, with magic wand or willow professed to be able to locate water or ore or even to track down criminals, to the geophysicist who uses scientific instruments to disclose subterranean secrets. Just as it was hard to convince certain people that those earlier seers were fakers, so is it now difficult to make the layman believe that their modern counterparts can foretell what will be discovered when a hole is bored in the ground. Yet, the two should not be confused. The mysterious gentleman who waved a crooked branch and muttered incantations overplayed his hand. He attempted to say that gold or water or whatever was sought would be found beneath a designated section of the earth's crust. The geophysicist makes no such claims. All he professes to do is to state whether or not there are indications of geological conditions that can be considered favorable to the occurrence of the material that is desired. The difference is a distinct and important one.

The witching-stick artist and the "doodlebug" expert that came after him both claimed occult powers. They denied that their magic could be performed by ordinary persons even with the charmed tools. The geophysicist, however, tells you frankly that he does not differ from any other mortal, except that he is trained to read his instruments and to interpret those readings in the light of established geologic principles. In other words, it is the instruments, not the man, that count most. In any event, it is not necessary to champion the cause of the geophysicist. The effectiveness of his work has been proved in numerous instances, and hard-headed businessmen count his services well worth their cost.

All geophysical methods are based on the fact that different subsurface materials transmit impulses of one sort or another at varying rates or with varying degrees of intensity. In some cases the impulses are present in the ground; in others they must be created and put there. The method most applicable in a given section is determined by existing conditions; and it is usually desirable to check the results of one method by another or others.

Practical uses of geophysical exploration are being extended all the while. In the construction field, it is particularly helpful in determining the general nature of the material that will be encountered in boring tunnels or in excavating for dam footings. Undoubtedly, the geophysicist could have saved tunnel builders of the past much money if he had been available. The Moffat bore through the Continental Divide in Colorado cost $18,000,000, as against an estimated cost of $6,760,000, the difference being attributable to "bad ground". Where rock was expected, soft, "cavey" earth was met. By way of contrast, those who are tunneling 90 miles of line for the Metropolitan Aqueduct from Boulder Dam to Los Angeles are having their course charted for them by this new science. So far, the conditions found have borne out the predictions made.

OUR COVER PICTURE

ALTHOUGH the 70-story R.C.A. Building in Rockefeller Center has been in use for a number of months, the construction-period photograph reproduced on our cover is one of the most striking studies of the structure yet made. The cameraman was stationed in the excavation for the foundation of an adjoining building where "Jackhamer" men were still at work.

THE 1845 MODEL COMPRESSOR

A GLIMPSE of the beginnings of the iron industry in this country is afforded by an article in this issue on the old iron furnace at Cornwall, Pa. Through the generosity of the owner, this interesting structure is now restored to the condition in which it last ran, 51 years ago, and will become a public museum under the control of the Pennsylvania State Historical Society.

In a sense, the old structure is hallowed, for from it came guns and utensils that helped win American independence. Washington and Lafayette both visited it in the pursuance of their duties. The two Grubb brothers who owned it at the time fought as colonels in the Continental Army. Hessian prisoners later gained their freedom by going to work there; and they remained to marry and rear families to which many of the present residents can trace their ancestorship.

Considered in the light of our present advanced steel technology, the furnace was a crude affair. Yet, in its day it was one of the finest; and the fact that it stood intact and operated at a profit for nearly a century and a half attests to its sturdy construction and sound design. A close inspection of the tubs and of their associated driving mechanism furnishes additional proof of the high order of craftsmanship that existed when they were created. Inasmuch as only hand tools were available, it must have been a tremendous task to put together a wooden wheel 24 feet in diameter, with spokes more than 9 feet long and arranged around a central wooden shaft 30 inches in diameter. Because of its size, this driving gear could not be assembled outside and moved into place as a unit; and there is evidence that it was brought into the building in hundreds of pieces, which were then carefully fabricated. Some of our modern installation feats seem simple in comparison.

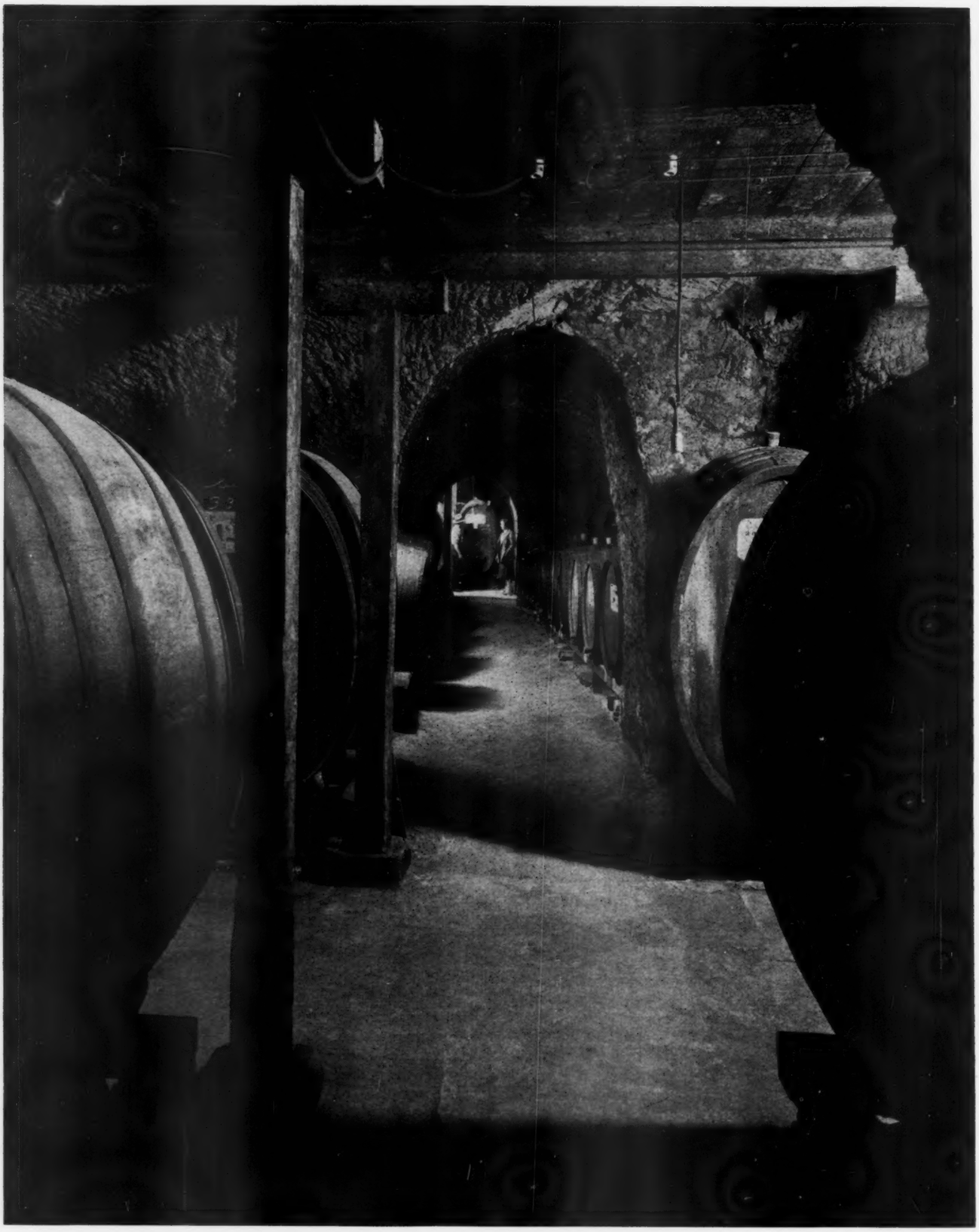
This structure should be especially interesting to our readers because it provided one of the earliest uses of compressed air in this country. The huge blowing tubs, which were in service there and elsewhere about 1845, utilized, for the first time, the principle of the modern reciprocating compressor in blast-furnace work. Even after iron supplanted wood as a material for such machines, the design remained much the same, and it was common practice to refer to the units as blowing engines rather than as compressors. It was not until comparatively recently that the turbo-blower made its appearance and revolutionized the procedure of supplying blast air for furnaces and converters.

WE STICK TO STONE

OUR article in the following pages concerning a modern establishment for shaping and carving stone memorials reminds us that, although the Stone Age is quite remote, we still cling to rock as a medium of artistic and emotional expression. Egyptologists are now translating from stone structures, characters and inscriptions that tell the story of civilizations long vanished. We consider ourselves different from those peoples, for we have mastered the secret of extracting iron from its ores and forming it into machines that have made human slaves unnecessary. And yet, when future archaeologists delve into the ruins that we shall leave behind us, it will be in stone rather than in steel that they will find the fullest account of what our age thought about and stood for.

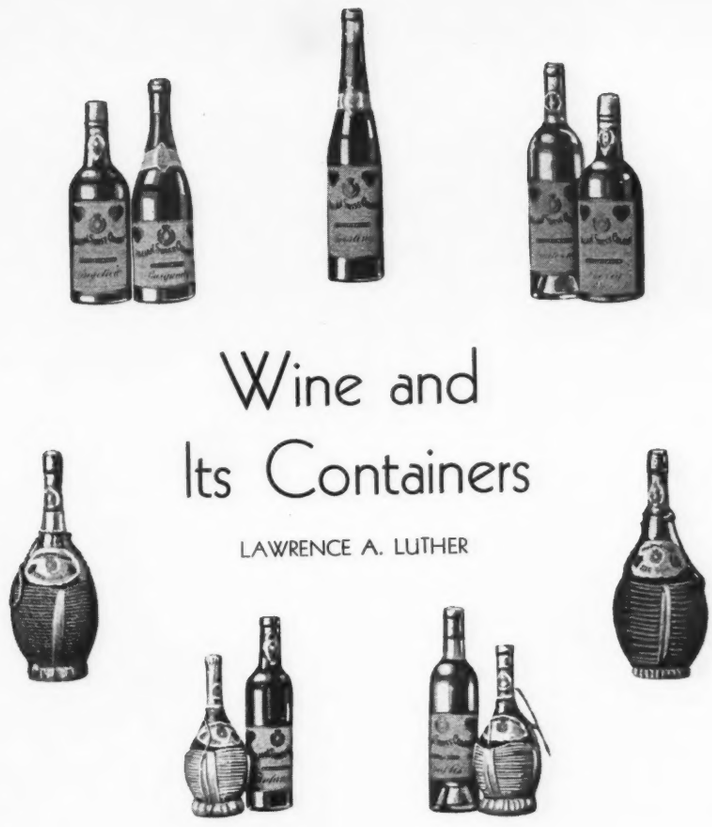
Ancient Pharaohs built pyramids to portray their power and pomp. But even before them, races, whose identity and characteristics are lost in antiquity, left stone megaliths and platforms whose exact significance still remains unknown. The Greeks, at the height of their glory, constructed acropolises a study of which reveals clearly what sort of people created them. Down through the ages the instinct to inscribe memorials in stone has persisted.

On the sheer face of Mount Rushmore in South Dakota, Gutzon Borglum is carving a nation's homage to its foremost presidents; and near Atlanta, Ga., the South is essaying to perpetuate in stone the memory of its heroes. All our public buildings contain cornerstones, suitably inscribed to tell when and why they were built. These are, in effect, statues to ourselves—public acknowledgments of our own professed greatness, just as the pyramids and acropolises were tributes to the power of the rulers and peoples of those ages. Thus, there has persisted not only the urge to publish human prides and passions for the benefit of succeeding generations but also the original medium of expression.



WHERE WINE ATTAINS CHARACTER

FOLLOWING its initial fermentation, wine is placed in huge casks, where it undergoes slow, secondary fermentation during which it generates carbon dioxide. This aging process gradually rids the wine of its turbidity by permitting the lees to collect in the cask bottoms. Wine aging has been conducted underground since time immemorial, because a fairly constant temperature can be maintained there. In some modern wineries, refrigeration is employed to obtain an even closer control of temperature. Shown here are portions of the aging cellars of the Beringer Winery, in Napa County, California. Hewn from solid rock over a period of many years, these extensive caverns are reminiscent of wine cellars along the German Rhine.



Wine and Its Containers

LAWRENCE A. LUTHER

SAMPLES OF THE BOTTLEMAKER'S ART

The glass containers in which wine is marketed are almost as distinctive as the beverages, themselves. These bottles, of any desired shape, size, or color, are today made by ingeniously contrived machines whose products are remarkably free from defects. Shown here are various wines of the Italian Swiss Colony at Asti, Calif., ready for marketing in bottles made by Owens-Illinois Pacific Coast Company.

CALIFORNIA now grows or manufactures within her borders everything that goes into the making of a bottle of fine champagne with the exception of the cork. Hence, with the passing of prohibition, there is every indication that the great vineyard-dotted area extending some 500 miles northward from San Diego will come into its natural heritage as one of the world's principal wine-producing centers. When Pacific Coast wine makers are in an optimistic mood they like to talk of the per capita consumption of that beverage in France—about 125 bottles annually—and to speculate on the demand for wine in this country as compared with beer and hard liquor.

In spite of the long legally dry period, such figures as are available indicate that the total consumption of wine did not decline but, rather, had a tendency to increase. It is generally conceded, however, that the exacting technique of wine-making suffered seriously, for selling grapes in the form of bricks, or shipping them far and wide for processing in the home, largely eliminated the expert winery staffs whose chief pride lay in turning out a superior product. Of the 700 California wineries that were in business in 1920, only some 150 were producing with the prospect of repeal in mind. Those few companies that valued the position their brands had assumed in the markets of the world, and that maintained well-stocked cellars and the nucleus of an operating force, stand ready to reap the reward for their patience and foresight.

In many instances California vineyardists and wine makers are carrying on family traditions that date back several generations and have their origins in famous wineries of the Old World—the art of wine-making, perhaps more than any other pursuit, still being largely handed down like a legacy from father to son.

Wine-making in California had its inception in the earliest colonizing and missionary days of the great monk Fra Junipero Serra and his padres. Back in 1796, after they had scarcely completed the first of the missions at San Diego, these holy men began to make sacremental wines from the wild grapes of the region. But these produced indifferent wine. It was not long, however, before vines grown from cuttings from the domestic grapes of Mexico, that gradually found their way northward along the El Camino Real, became, with the olive and the fig, a part of every mission garden. There were about 2,000,000 grapevines in the California missions when Father Serra died, and some few of these still flourish. One near Santa Barbara, that now has a trunk 10 feet in circumference and covers an area of 10,000 square feet, yields on an average 10 tons of grapes annually.

Wine became a staple commodity of barter with the early Spanish ranchers, and some of it doubtless was handled in goatskin sacks. But when gold and the lure of adventure on our most romantic of frontiers had brought thousands of men from the East and from Europe, California's aggregate thirst rapidly outstripped the local supply, and domestic and foreign shipments coming around the Horn created a thriving import liquor business. As the gold fever waned, some of the new citizens resumed their Old World pursuit of grape culture. In 1861, California's governor commissioned a Hungarian nobleman, Colonel Harazthy, to gather cuttings of the best European varieties, and some 150,000 vines were planted at Sonoma. The industry grew rapidly as a result of the wide distribution of this stock; and about 225,000,000 bottles of wine from those grapes—one-twentieth of the production of France—were being supplied annually during the years preceding the Volstead Act.

It seems that only the initiated fully appreciate the different kinds of soil, climate, processing, and aging—in some instances, blending—that go into the making of the finer domestic and foreign vintages, giving them their distinctive flavor, color, and bouquet. In California, with its diversified soils and climatic conditions, certain areas have been proved to be peculiarly endowed to produce certain wines.

Extensive vineyards in Southern California and the San Joaquin Valley appear to be especially suited to the growing of the varieties of grapes that are used in the manufacture of

PRODUCING SAND FOR MAKING BOTTLES

Until comparatively recently, much of the sand used by Pacific Coast glassmakers came from Belgium. Persistent prospecting disclosed, however, that the Coast Range contained siliceous sandstones suitable for the purpose, and these are now being mined extensively. Scenes at two of the leading properties are reproduced here. At the upper left is shown the entrance to the Hazel Atlas Glass Company's mine near Pittsburg. Below it is a 2-stage, air-cooled portable compressor that supplies air to the workings. At the top center is a double-drum "Utility" air hoist used for slushing in the stopes, and to the right of it a driller is pictured using an RB-12 "Jackhamer" with auger drill steel. The view at the lower right shows the entrance to the Brentwood Mine of the Silica Company of California, which furnishes sand to the Owens-Illinois Pacific Coast Company.

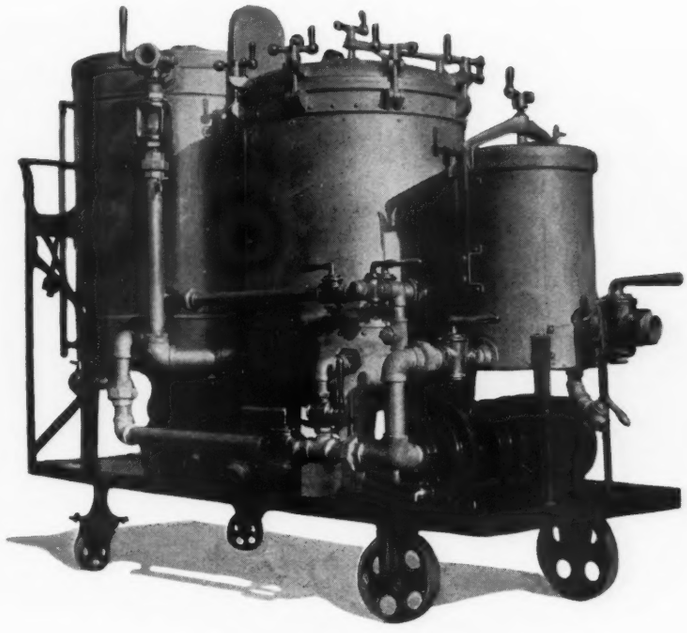
sweet wines—of Muscatel, Sherry, Port, Angelica, and others. At Guasti, near San Bernardino, is what is said to be the world's largest vineyard, covering more than 6,000 acres. A system of privately owned railway tracks is maintained to bring in the harvest from this vast domain.

Wineries in that section of the state extending from San Francisco Bay northward into the Redwood Empire have distinguished themselves with their different brands of dry and sparkling wines, which have taken several cherished high awards abroad. Typical of the larger and older institutions in this section is the Italian Swiss Colony winery, which is located at Asti in the Russian River country some 80 miles north of San Francisco. This firm is best known for its "Tipo" red and white wines; and it carried off the grand prize at the Turin International Exhibition, held in 1911, with its "Golden State Champagne".

Founded in 1881, this plant gradually grew in the pre-Volstead years to a sizable industry. During the 1933 harvest about 250 people were employed in the plant and winery, although the year-round working force averages about 100. Having lived up to its slogan, "Every year a vintage year", throughout the long and discouraging drought, the Italian Swiss Colony now has on hand a vast stock of aged wines. Some 2,000,000 gallons were added in 1933; and the present equipment is sufficient to produce 3,000,000 gallons annually.

At Asti, grapes are delivered by train and truck to two crushers, which handle them at the rate of 300 tons per day at the height of the season. The crushed grapes, known as must, are pumped to fermenting tanks. In the case of red wines, the grapes are allowed to ferment with the skins on for a period ranging from four to seven days so as to attain color and flavor, while the free liquor to be used for white wines is drawn off immediately. Residual pulp is dumped from the tanks into sumps and conveyed mechanically to two large rotary presses—the wine thus obtained being of a lower grade than that from the free liquor. Mr. Coppo, the chief cellarman—who comes from a family for several generations back of expert Italian wine makers, utilizes a pasteurizer and a refrigerating plant in maintaining the several hundred casks and vats in the winery at the desired stages of fermentation. Of all the available storage facilities, quite the most remarkable is an underground tank that has a capacity of 500,000 gallons.

No artificial sweetening is employed. Grape syrups are produced for this purpose by an evaporator served by a 22x8-inch ER-1 vacuum pump. This equipment was used during the years prohibition was in force in making large quantities of grape concentrates. Two grades of brandy are distilled; and cream of tartar is extracted from the final residue, or lees, by storing it in small conical, concrete vats in which are suspended ropes to which the tartar adheres. The utilization of substantially every part of the grape suggests the present-day practices in packing plants and petroleum refineries where nothing is wasted and all the by-products are made to serve a useful purpose. A dozen kinds of wine are now being marketed by the Italian Swiss Colony, and the probability is that this figure will be increased to fifteen, including champagne, which, as some of us know, is a blended wine demanding great care and expertness in its preparation.



PORTABLE WINE FILTER

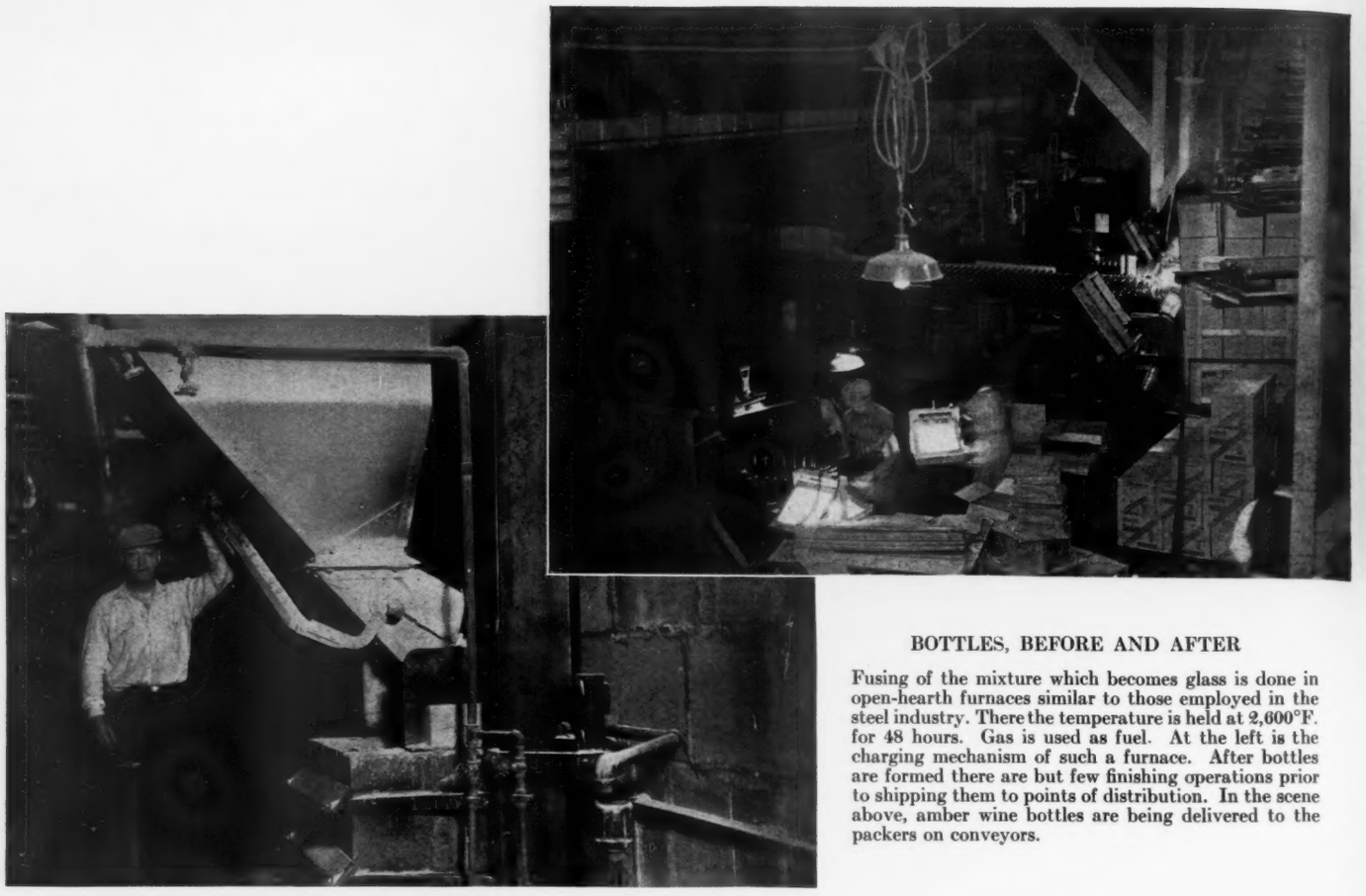
Although wine is largely clarified by natural processes, the better grades are filtered to insure against the retention of solid matter. This picture shows what is known as the West Coast Alcoholic Beverage Filter. It consists of Johns-Manville filtration units and a Cameron Motorpump for circulating the wine.

Before marketing, all the better wines are filtered, and to this end the larger plants are provided with elaborate facilities and with accessory washers and presses for reclaiming the filter cells used. Conspicuous among the ready-made equipment in this service is a complete portable unit employing a Johns-Manville filter and a Cameron RV Motorpump in effecting circulation. This is known as the West Coast Alcoholic Beverage Filter, and is produced, in capacities ranging from 500 to 3,500 gallons per hour, by the West Coast Machinery Company, of San Francisco.

Obviously, large quantities of serviceable and artistic bottles are an indispensable item in the rebirth of this great Pacific Coast industry. Until recently, an occasional tramp steamer making its way through the Golden Gate carried ballast of Belgian sand, which was sold to Pacific Coast glassmakers. But, even though there is a nominal duty of only $2 a ton on this sand, still their aim is to make themselves independent of foreign sources of supply. Therefore, groups of men are continually searching for and finding it somewhere on this vast continent—something that might be said for nearly every base and precious mineral we require.

Typical of such finds are the deposits of siliceous sandstone that occur relatively close to the surface in the Coast Range Hills and at other points adjacent to the San Joaquin Valley. They are now being worked commercially in California and used in steadily increasing quantities in the manufacture of glass. Though having the common characteristic of friability, the material in the several beds varies widely in hardness and in color and chemical content. Viewed in true geologic perspective, these deposits are of comparatively recent origin even though they were actually formed many thousands of years ago when the great inland valleys of California were underwater. As the ancient and uncharted sea gradually subsided, the surf along the ever-changing shore line produced the stock of excellent raw material that is now being used in the manufacture of bottles and fruit jars so essential to certain of our western industries. The sandstone is being worked from a series of tunnels and stopes—in short, by a procedure much like that followed in metal mines.

Glass-making on the Pacific Coast dates back to the early eighties, when a small plant, known as the Pacific Coast Glass Works, was built. In 1898, construction was begun at Fifteenth and Folsom streets, on what is now the largest factory of its kind in San Francisco. The great fire of 1906 stopped just short of this property, which was saved from destruction by dynamite only after the owners, after much persuasion, were able to convince the police and firemen that the flood of hot, molten glass which would thus be released from the furnaces would speed rather than check the advance of the flames. Lung power for the blowing of glass was resorted to exclusively in this plant until 1915, when machines were installed to do this work. These facilities, and a factory built in 1928 at Los Angeles, were managed by the Illinois Pacific Glass Corporation until their acquisition recently by the Owens-Illinois Pacific Coast Company, a subsidiary of the Owens-Illinois Glass Company having headquarters at Toledo, Ohio. That company now operates the two plants just mentioned, as well as a third



BOTTLES, BEFORE AND AFTER

Fusing of the mixture which becomes glass is done in open-hearth furnaces similar to those employed in the steel industry. There the temperature is held at 2,600°F. for 48 hours. Gas is used as fuel. At the left is the charging mechanism of such a furnace. After bottles are formed there are but few finishing operations prior to shipping them to points of distribution. In the scene above, amber wine bottles are being delivered to the packers on conveyors.

located at Seventh and Irwin streets, in San Francisco. The names Owens and Illinois, it should be said, are synonymous with significant developments in the early and present-day manufacture of glass for commercial purposes in this country.

Restoration of the wine industry has resulted in an unprecedented and urgent demand for bottles of the various styles required today for the old and the new brands that are being put on the market. The several raw materials needed for the making of glass are unloaded from railway cars and elevated by mechanical means to suitable storage bins. Sand for the production of amber bottles is used virtually as it comes from the mine, its treatment at the sand-processing plants being confined to screening and washing. In the case of the clear-glass bottle, however, the sand has to be leached for some time in vats in order to remove the contained oxides of iron. This assures the necessary transparency.

Sand will not melt at any ordinary temperature without the addition of a flux. Soda ash is employed for this purpose, its proportion in the finished mix amounting to about 18 per cent while sand averages 55 per cent, lime about 12 per cent, and feldspar and borax are used in quantities of approximately 2 per cent. The latter ingredients increase the hardness and brilliance of the finished product and improve, as well, its viscosity and workability during the manufacturing process. About 12 per cent of cullet, or reclaimed glass, is usually added to each charge placed in the furnaces.

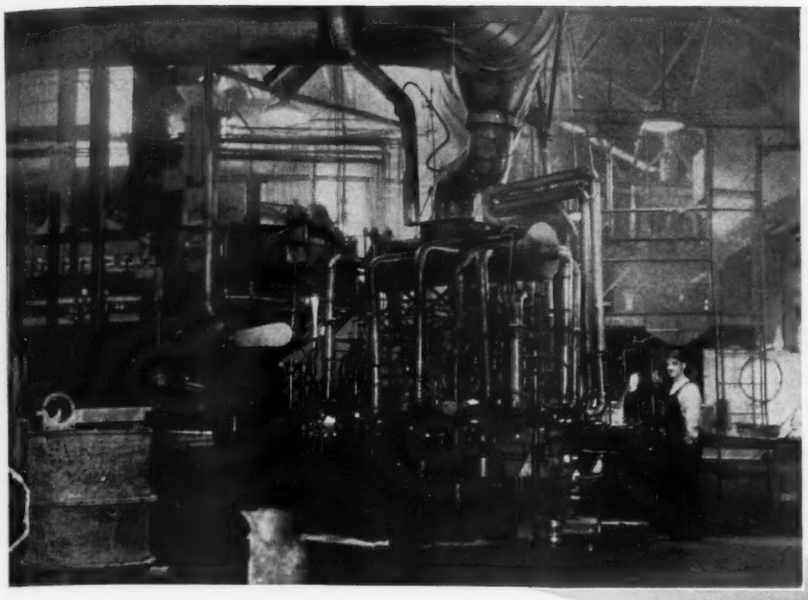
The proportioning of the various ingredients is done carefully by weighing. Chutes in the different storage bins discharge the materials into mine cars, and, after a batch has passed through a rotary mixer, it is elevated to storage bins located above the furnaces. The initial charge for a furnace weighs about 2 tons. The cycle of operations is a continuous one—the plants being run on three 8-hour shifts and the furnaces periodically replenishing themselves as the molten glass is consumed by the machines. The furnaces used are of the open-hearth type, and are somewhat akin to open-hearth steel furnaces. They are fired with natural gas discharging through jets operating on the recuperative system—fires being maintained alternately on opposite sides of a furnace at half-hour intervals.

In the melting process, the mixture produces certain gases and in sufficient volumes to create objectionable bubbles. But approximately 48 hours of "fining" at a temperature of 2,600°F. serves to dissipate them and to assure a glass of the clear, homogeneous texture desired. The automatic bottle-making machines most generally employed are of the Lynch and Miller types, a so-called "drop blank" Miller machine being assigned to the manufacture of wide-mouth jars such as are commonly used in marketing preserves or mayonnaise.

The molten glass flows to the machine by gravity; and a billet or, in the nomenclature of the shop, a "gob", of the size required to produce a bottle or jar, is formed either by shearing it like taffy from a stream pouring through an orifice or by an automatic plunger operating in a metering chamber. To the uninitiated, the machines work with an uncanny precision which is attributable to the fact that all their manifold units are interlocked with a single drive that assures perfect synchronization of the many movements so rapidly performed by them.

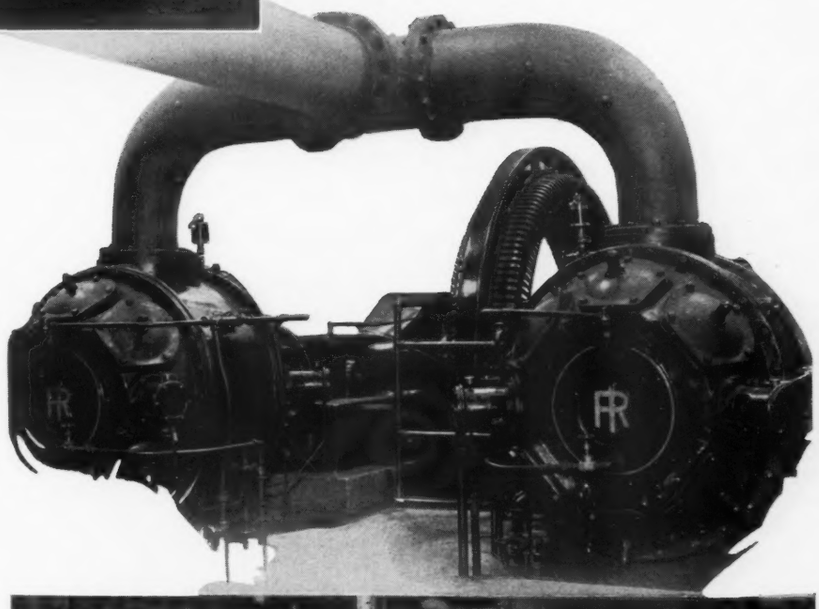
A description of the cycle of operations of a machine forming a wine bottle such as is conventionally employed for Sauterne is fairly typical of them all regardless of the product. The Lynch machine in service consists essentially of two rotating tables, each carrying eight cast-iron molds having bilaterally symmetrical halves working on hinges. As the shears cut off a glowing billet of glass it falls into a blank mold, the bottle in the making now being in an inverted position. A plunger and die, designed to shape the neck ring, then enter the mold from the bottom, while a blow-head, discharging air at 40 pounds pressure, covers the top of the mold and forces the blank down to form the ring.

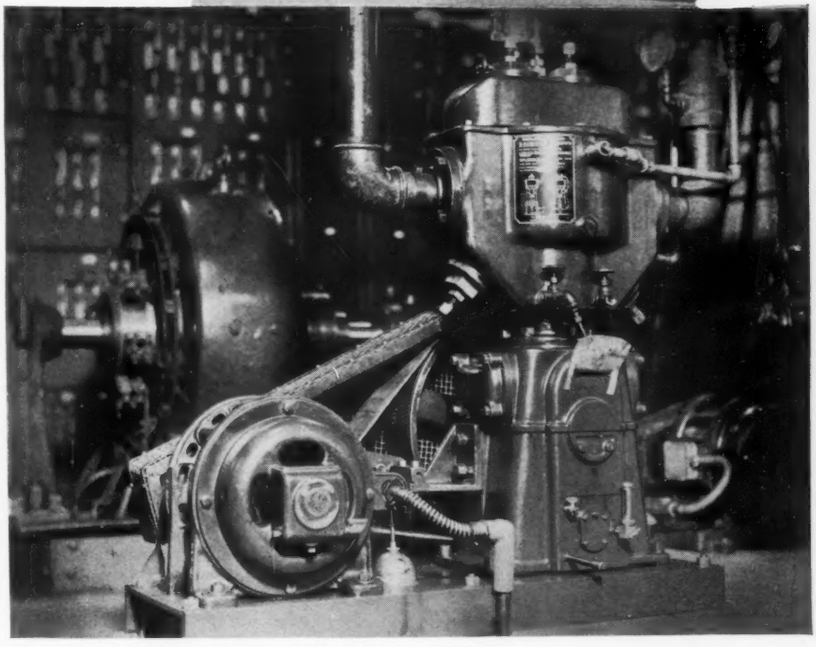
Before the next operation can take place, the product is turned right side up. With this done, another blowhead partially distends the plastic mass almost to the bottom, after which it is still further expanded before the inclosing mold opens. From there the bottle is transferred to a finishing mold, on the second table, where it is gradually distended by a succession of operations and its neck ring is precooled by air jets. Upon being released by this mold as a



TURNING OUT BOTTLES AUTOMATICALLY

Bottle-making involves a series of operations, but all of them are performed on a single machine. The one pictured at the left is in one of the plants of the Owens-Illinois Pacific Coast Company and produces from 1,200 to 1,400 perfectly formed bottles an hour. The glass furnace is at the left of the machine, and a stream of molten material may be seen as a white streak falling into a mold. Bottles are delivered to a conveyor which carries them through a lehr or annealing furnace. Compressed air and vacuum play highly important parts in manufacturing bottles. Two of the units which supply them are shown here. Just below is a duplex, single-stage, synchronous-motor-driven compressor which has a capacity of 4,000 cfm. of free air. The bottom illustration is of a Type 15 vacuum pump.





finished bottle, a steel hand transfers it quickly to a short endless conveyor which is kept hot by a gas flame applied to its idle side. Two bottles are forming simultaneously on each of the two tables of a machine, and the hourly output per machine is from 1,200 to 1,400 bottles.

The short conveyor just mentioned carries the bottles to the lehr which serves each machine. This consists essentially of a gas or electrically fired annealing furnace, held at a maximum temperature of 950°F., through which moves very slowly a 4-foot-wide endless belt conveyor. A 2-armed stacker picks up the bottles by their necks from the first-named conveyor and loads them in precise rows on to the second conveyor for their trip through the furnace. After a 2-hour annealing period at graduated temperatures they emerge at the packing-room end of the lehr, and by that time are already relatively cool. There they are given a final inspection for weight, fit of cork, and perfect proportions before they are packed in cartons or crates for storage or for immediate transfer to cars. The machine operators also are provided with scales, and they watch the product continually for defects. A large sign above each lehr bears this cautionary message: "If in doubt, throw it out"; and if people a century hence should collect these bottles, as we collect early American glass today, these diligent workers and inspectors may prove to have contributed something more than just containers for beverages.

Compressed air in large volumes has supplanted the lung power of the old-time glass blower, whose life was often measurably shortened by the rigors of his trade. Reliability and perfect control of the air supply are the keynotes of successful glass manufacture, for a break in the cycle is apt to cut down production. Machines that operate economically at virtually constant pressure by the use of multi-step clearance-control regulation have been chosen as the principal sources of air supply for both of the San Francisco plants previously referred to. The plant located at Seventh and

WHERE GRAPES WERE NURTURED

California traces its wine industry to the monks who came up the coast from Mexico and established the first missions. Finding the product of the wild grapes of the region unsatisfactory, they began introducing cuttings from Mexico, and from these, in part, has been developed the fine stock that exists today. Shown above is the largest and best preserved of the old California missions, that of San Juan Bautista at San Juan.

Irwin streets is equipped with a 16&16x14 XRE compressor, with three smaller machines of the XB type which serve as standbys, and with a 5x5 Type 20 vertical unit that furnishes high-pressure air for paving breakers and other tools required in periodically repairing the furnaces. A 25&25x24 PRE-1, which has an output of 4,000 cfm., is in the Fifteenth and Folsom streets factory, where the small volume of high-pressure air needed is provided by a 5x4 ER-1 unit acting as a booster in the low-pressure line.

In the Los Angeles plant, two 18&18x14 XRE compressors make available a total air supply of 3,260 cfm.; and marked advantages have followed the installation of two aftercoolers which remove all objectionable moisture from the air before it is delivered to the bottle-blowing machines. By passing the air directly from the compressor discharge through an ingeniously arranged heat interchanger, the temperature of the fuel oils burned in the glass furnaces can be raised sufficiently to assure perfect atomization.

Vacuum as an aid in bottle manufacture is of more recent date than the use of compressed air. In the San Francisco factory last mentioned, a Type 15 vacuum pump has been installed to help in forming the neck ring and the corkage area of some of the more intricate bottles. In this case, air pressure and vacuum might be said to collaborate: the compressed air serving to force the blank down while the vacuum draws the molten glass into the recesses of the die.

In supplying the requirements of domestic and foreign customers, the diversified products turned out annually by the Owens-Illinois Pacific Coast Company plants now include more than a thousand styles of bottles and jars.

The writer wishes to acknowledge his indebtedness especially to P. D. Burtt, general plants manager of the Owens-Illinois Pacific Coast Company, and to K. M. Henry, plant manager, for the courtesies and assistance extended to him in collecting data and photographs.

Safer Fumigation

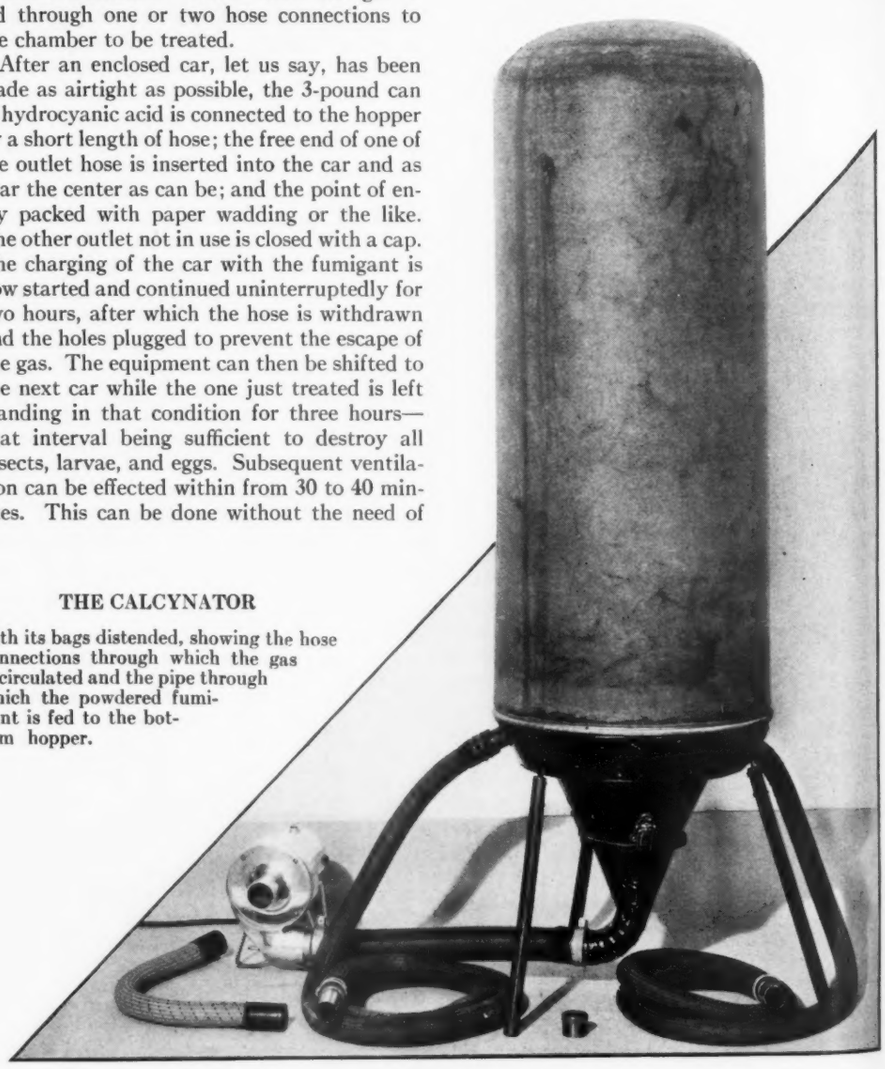
FUMIGATION by mechanical means without endangering human life is practicable. The device by which this can be done is called a "Calcynator." It was originally designed for use in connection with flour mills; but, in the meantime, has been found to be equally suitable for disinfecting certain kinds of enclosed spaces, including loaded and empty railroad cars of all sorts.

The fumigator is self-contained and is set up outside of the room or car to be disinfected. There, out of harm's way, it can be made to do the work from start to finish. It consists essentially of a hopper and of two bags, one inside the other, mounted on top of it. The fumigant used is powdered hydrocyanic acid or "Calcyanide" which, upon admixture with air, liberates a gas that is deadly to insect pests. From its original can or container, this powder is forced into the hopper by a current of air and carried into the first bag with the air, thus inflating it. This inner or filter bag serves to prevent dust from being blown into the area being fumigated. The gas that is generated flows into the outer bag, which also becomes distended. From there the gas is fed through one or two hose connections to the chamber to be treated.

After an enclosed car, let us say, has been made as airtight as possible, the 3-pound can of hydrocyanic acid is connected to the hopper by a short length of hose; the free end of one of the outlet hose is inserted into the car and as near the center as can be; and the point of entry packed with paper wadding or the like. The other outlet not in use is closed with a cap. The charging of the car with the fumigant is now started and continued uninterruptedly for two hours, after which the hose is withdrawn and the holes plugged to prevent the escape of the gas. The equipment can then be shifted to the next car while the one just treated is left standing in that condition for three hours—that interval being sufficient to destroy all insects, larvae, and eggs. Subsequent ventilation can be effected within from 30 to 40 minutes. This can be done without the need of men entering the gas-laden atmosphere by leaving at least one window on opposite sides of the car unlocked so that they can be opened from the outside.

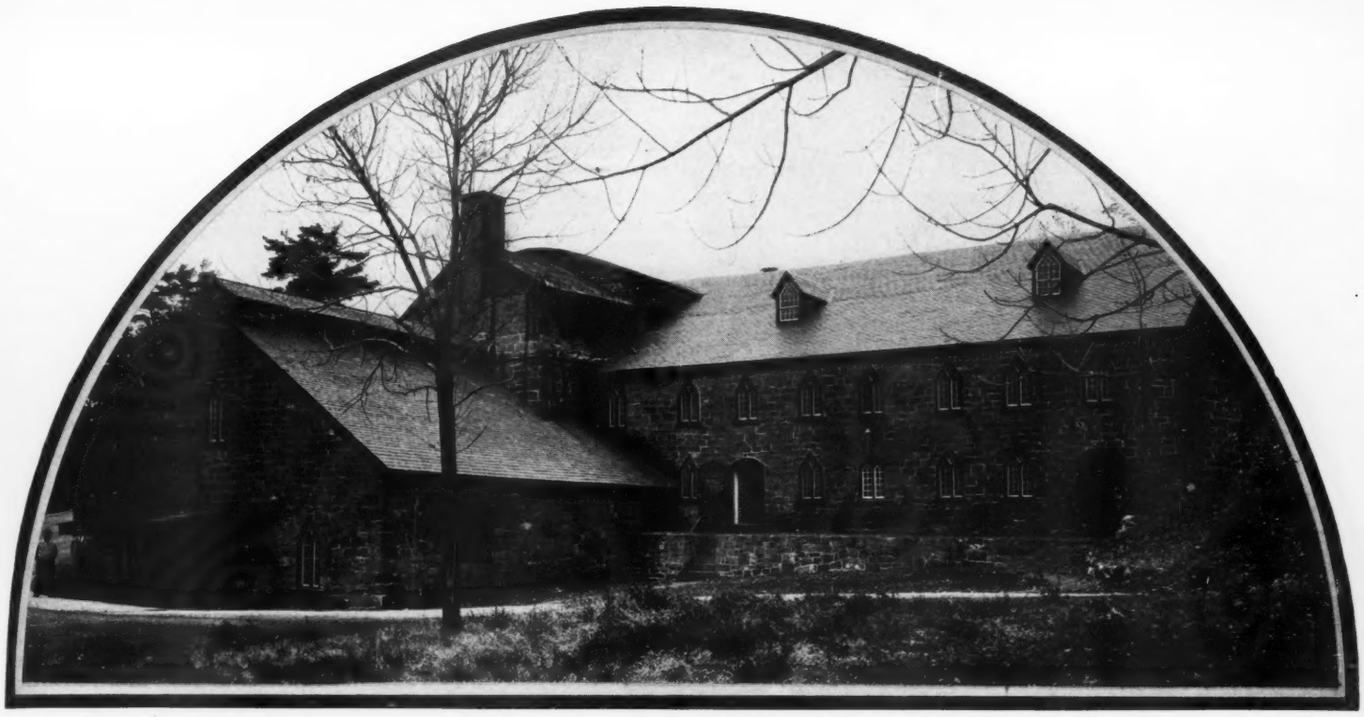
The foregoing applies to the fumigation of empty cars, only: the procedure and duration vary somewhat for loaded cars and furniture vans, homes with hot-air furnaces, flour mills, etc. In the case of the latter, it is possible to fumigate only the machinery and equipment contained therein, if that be desired. This can be done over a week-end or other idle period, and without the necessity of dismantling any part of the plant or of sealing it. Four elevators with connecting spouts and equipment can be thoroughly fumigated in one hour and at a cost of about 80 cents an elevator.

When set up for service, the "Calcynator" is about 60 inches high; and to facilitate carrying it about it can be dismounted to fit into a case 18 inches in diameter and 17 inches high weighing, combined, approximately 30 pounds.



THE CALCYNATOR

with its bags distended, showing the hose connections through which the gas is circulated and the pipe through which the powdered fumigant is fed to the bottom hopper.



CORNWALL FURNACE AS IT NOW APPEARS

Seven years were spent in laying out and in constructing this Colonial iron-making plant which was opened in 1742 and maintained production until 1883. The massive walls are built of brown sandstone, which was also used for the numerous other structures required for carrying on the operations. The furnace, itself, occupies the central portion of the building. The iron was drawn from the furnace into molds in the wing on the left. The right-hand wing contained the blowing equipment and sleeping quarters for some of the employees.

A Blast Furnace Nearly 200 Years Old

C. H. VIVIAN

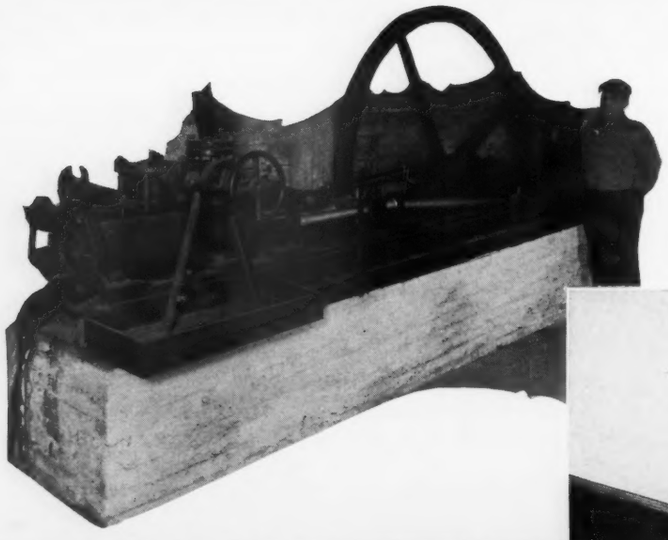
SO MUCH has been written about the indispensability of steel and iron to our modern civilization that to dwell upon that topic here would be merely to reiterate familiar facts. Today we have so many steel plants that the recent paramount problem has been to find work for all of them. At this writing, pig-iron production in the United States stands at only about 47 per cent of the aggregate furnace capacity; but, even so, it is more than double the low mark of the depression. It is not alone the number of existing plants that complicates matters but also their individual size. In reality, the number of establishments has been diminishing for some years, but at the same time the average plant size has been increasing. In the Pittsburgh district there are steel mills under one management that stretch out for nearly five miles virtually without a break. The economies that result from concentrating operations in a relatively few large establishments are more than sufficient to offset the savings in transportation of finished products that could be made by scattering a large number of small plants throughout the land.

This, of course, was not always so. As we have already implied, the development of huge iron-working factories was made possible by improvements in transportation facilities. Eighty-seven per cent of the iron ores reduced in this country now come from the vast deposits in the upper Great Lakes region. In locating steel mills, more attention is paid to the availability of fuel and the proximity of adequate markets than to the nearness to ore supply. This close relationship of iron production to transportation is one reason why the general economic health of our nation varies with that of the steel industry. Steel gives rise to a great volume of transportation and handling at both ends—first the raw materials and then the finished products. Seamless steel tubing which is employed for casing oil wells in Texas and Oklahoma is obtained largely from Ohio and Pennsylvania. Plates from which the huge Boulder Dam penstocks are being formed were rolled at Gary, Ind., 2,000 miles away. New York City is the largest consumer of structural steel, yet it has no steel mill close at hand. Both iron ore and steel, then, are wide travelers, and their movement and handling and working involve so much human labor in one way or another that prosperity in the steel industry serves to put money into the pockets of hundreds of thousands of workmen.

When our country was younger, present conditions were reversed. Haulage facilities were meager, and every community was sufficient unto itself in so far as it could make itself so. Self-sufficiency meant having means for extracting iron from its ores, refining it, and working it into required shapes. Accordingly, wherever workable iron ores were discovered, regardless of whether they were rich or lean, one or more mills for treating them sprang up. Oftentimes, these antedated the foundation of villages, for the ironmasters knew that their establishments would soon attract residents.

Until about Civil War times this economic order prevailed, and primitive iron-working plants were scattered far and wide. Blast furnaces for producing pig iron, puddling furnaces for forming wrought iron, and Catalan forges for hammering the heat-softened metal into various shapes became landmarks. Travelers asked not the distance to the next town, but to the next forge: they knew there would be some sort of community close at hand. When Washington became president, iron was being made in all thirteen colonies. By 1810 there were 530 forges and bloomeries in the country. The value of their production in that year was $13,000,000; and $4,000,000 worth of iron was also imported from England. The first hint of the existence of the huge ore deposits of the Lake Superior region, which formed the principal supply for the growth of our present gigantic steel industry, did not come until 1840. Their actual discovery was made four years later, when William A. Burt, in charge of a surveying party, noticed the erratic behavior of his compass needle and was moved to search for the cause of the deflection.

These early iron-working establishments, crude but all important in their day, existed by



HOW POWER WAS SECURED

The blast of cold air which was used in reducing the ore was originally supplied by a bellows driven by a water wheel. In 1845 the plant was converted to steam operation, when wooden blowing tubs, which are illustrated on the opposite page, replaced the bellows. At the same time the furnace was enlarged and its capacity doubled. Steam was produced in two 21x3-foot boilers which were installed at the base of the stack surmounting the furnace (below) and were heated by the hot gases which had previously been wasted. This steam was used at 40 pounds pressure in the 10-hp. engine shown at the left.

virtue of the abundance of timber that was to be found almost everywhere. From it came the charcoal that was universally used as fuel. Some commentators estimated that the trees were so numerous that the supply would never be exhausted, although at that very time England was decrying the desolation that had been wrought in her fine oak forests by the iron industry. Later, of course, charcoal was to give way to coal and then to coke, and the turn from the original fuel exerted a very potent influence in centralizing the making of iron in those areas that afforded ample and accessible supplies of coal. Incidentally, it may be noted here that the United States continued using charcoal for 90 years after the practice had been dropped in England, the reason undoubtedly being the wealth of forests that then covered this country.

The first discovery of iron ore by the colonists is credited to Ralph Lane and Thomas Heriot, leaders of an expedition to North Carolina sponsored by Sir Walter Raleigh. They made the find in 1585 on the Island of Roanoke while hunting gold. It was 23 years later, however, when the first ore was shipped to England by the Jamestown settlers. From the 35-ton lot was made 17 tons of iron, and its quality was reported to have been equal to the finest obtainable.

In 1619 the London Company sent to Virginia some 150 men who were skilled in the art of producing iron. It was intended to build three iron works in the colonies, but only one was ever operated. Indians attacked and detroyed it in 1622, killed 347 persons, including John Berkeley, the master, and it was many years thereafter before another establishment of the kind was started in the colonies.

The next efforts took root in New England, and were successful. By 1731 that section of the country had six furnaces, nineteen forges, and a nail factory. All the early plants produced wrought iron, and most of them had facilities for hammering the bloom that came from the furnace and thereby purifying it. It was not until 1727, in Pennsylvania, that the first iron was cast, although methods of doing this had been known in Europe nearly two centuries earlier.

Of the hundreds of primitive iron works that were constructed, few have survived except as ruins, and great interest therefore attaches to any that have been preserved sufficiently to admit of intelligent exploration. Fortunately for industrial historians and for posterity in general, there exists at Cornwall, Pa., a blast furnace nearly 200 years old that is in such condition that it could be set going tomorrow. Through the generosity of Mrs. Margaret Buckingham, a member of the family which owned and operated it as far back as 1786, it has been restored to working order and presented to the State of Pennsylvania together with a fund large enough to maintain it and to provide a caretaker who will also serve as a guide for visitors interested in the property. This furnace, which was known as the Cornwall Furnace, was not the first established in Pennsylvania, but its record of having operated continuously for 141 years is said to have been unequaled by any similar plant in the country.

Cornwall Furnace, which was the first erected in Lebanon County, owed its location

WHERE FURNACE WAS TAPPED

The picture in the rectangle above shows the front arch or forepart of the furnace and, in front of it, reconstructed sand molds such as those into which the molten metal was directed through channels in the floor. At the extreme left of the furnace is a lever which the furnace keeper manipulated when he wished to shut off the air blast. This was connected with the escape valve (bottom) at the rear of the furnace. This valve was a wooden box having a door that could be opened to permit the air to escape to the atmosphere instead of flowing through the piping to the three tuyeres that served the furnace.

to the nearby iron ores which are still mined. The original owners apparently did not recognize the character and value of the deposits, for they made no effort to work them and disposed of 300 acres of them for 135 pounds Pennsylvania currency—equivalent to $360 in our money. The buyer was Peter Grubb, who also purchased 142½ acres of adjoining ore-bearing land from the heirs of William Penn and 160 acres additional on which to erect his furnace.

Peter Grubb was the son of John Grubb, who emigrated from Cornwall, England, about 1679 and took up land where the City of Chester, Pa., now stands. The son was born in either 1707 or 1708, and by the time he started his enterprise at Cornwall he had already acquired the title of ironmaster through having constructed and operated two Catalan forges on Hammer Creek, a short distance from the ore banks. It is probable that Cornwall Furnace was several years in building. It is a substantial structure with thick walls of a brown sandstone that occurs locally and was put to extensive use in putting up other buildings which still stand in that area. The quarrying and shaping of the stones that entered into the furnace and related structures must have consumed considerable time, aside from the work of assembling them and the other materials. The iron members employed as braces in the furnace, itself, were procured in England, and were undoubtedly many months in arriving. The most accurate account fixes 1735 as the year that the furnace was laid out. It is well established that operations began in 1742.

Cornwall Furnace was originally run by water power. On a hillside above the building can still be seen traces of a small reservoir which provided the necessary head; and leading from it to the furnace are the remnants of an 8-inch pipe line. From the layout it is evident that an overshot waterwheel was used. This was rigged up to work a bellows that supplied air for the blast. This bellows was 20 feet 7 inches long, 5 feet 10 inches wide across the breech, and had a nozzle opening 14 inches in diameter. There was but one tuyere, or opening, into the furnace for introducing the air. During this period of its operation, thirteen years, the furnace was 32 feet high, 21½ feet square at the base, and 11 feet square at the top. Production amounted to 20 tons of bar iron a week, being limited chiefly by the available water supply.

In 1845, the furnace was converted to steam operation. This made it possible to increase the output, although it was first necessary to enlarge the structure. In its new form it had a base 28 feet square and a top 20 feet square, the height remaining at 32 feet. This reconstruction also provided it with three arches—one at the rear and one on either side, and each was framed with an opening for admitting blast air. The interior of the furnace, where the actual reduction of the ore took place, varied in width from 3 feet in the lower or hearth section to 7 feet in the upper or bosh jacket section. These changes resulted in increasing the capacity to 40 tons a week.

The machinery for supplying the blast air is especially interesting and furnishes a sharp contrast to the equipment nowadays available for a similar purpose. The principle was akin to that of modern reciprocating compressors, in that pistons were caused to move in cylinders to compress the air in one end of them. There were two of these cylinders, each about 4 feet in diameter and 7 feet long. They were made up of wooden staves, reinforced by encircling bands of iron, and similar in construction to a barrel save that their sides were straight and their diameter uniform throughout their length. These cylinders, or blowing tubs, as they were known, were set up in vertical position. The pistons working in them were actuated by drive rods connected by cranks to either end of a shaft below on which was mounted a large wheel that was both a drive wheel and a flywheel. The pistons had a 5-foot stroke. The cylinders were fitted with leather valves and discharged, at about 2 pounds pressure, into a common, centrally disposed box or manifold which, in turn, delivered air to the blast pipe.

Virtually all this blowing equipment was fashioned of wood, and must have required expert and painstaking workmanship in its manufacture and assembly. Accompanying illustrations give a good idea of its size and appearance. The drive wheel received its power through a geared connection with a shaft that was extended through a wall from a steam engine in an adjoining room. This engine, which is also pictured, delivered 20 hp. It had an 8x24-inch cylinder and ran at 10 rpm. Existing records indicate that it was purchased through the Lebanon Machine Works. Steam at 40 pounds pressure to operate this engine was provided by two boilers, each 21 feet long and 3 feet in diameter. These were installed in horizontal position at the base of the stack which received the hot gases from the furnace, thereby utilizing the heat which would otherwise have been wasted. An inspection of this ponderous blowing apparatus cannot help but incite a contrasting mental image of its modern counterpart—the compact, high-speed turbo-blower with a capacity for blowing up to 1,000 tons of pig iron in a day.

The furnace was charged through a 17-inch circular opening at the top. A charge consisted of equal parts of ore and charcoal and a small amount of limestone. Charges were first transported in boxes, later by means of iron buggies, of which a number have been preserved. All activities were carried on in two 12-hour shifts. Operations could be carried on by three men, and this number sufficed at night, although the day force was probably larger. A keeper, engineer, and top filler comprised the night shift. It was the custom for the day man to prepare

THE BLOWING MECHANISM

Power from the steam engine was transmitted through a shaft geared to a wooden wheel 24 feet in diameter (right). At either end of the 13-foot 7-inch shaft on which this wheel was mounted connections were made with wooden drive rods that operated pistons in two overhead blowing tubs, thereby compressing blast air to about 2 pounds pressure. An upward view along one of these drive rods, showing the crosshead and piston rod entering a tub, is given in the upper picture. These tubs, which were constructed of strap-bound staves, discharged into a box or manifold situated centrally between them. The pipe leading from this box to the furnace is visible at the lower right.

WHERE THE BLAST ENTERED THE FURNACE

The cold blast was piped from the blowing tubs to arches at the base of the furnace in the rear and at each side, where it was directed into the crucible through tuyeres. The left-hand picture shows the rear arch and the other one of the side arches. The air-blast main was 15 inches in diameter, with smaller penstocks leading from it to each tuyere. At the end of each penstock was a blowpipe which tapered to smaller size at the outlet end. The arches are notable for the excellence of their masonry.

the charges for the top filler on the night shift, possibly because he had ample light in which to work.

The engine room was at a higher level than the furnace keeper's station; and there is evidence of a bell signal system which the keeper operated by pulling a wire. Local tradition has it that several generations of engineers were also cobblers, and that they utilized their spare moments in looking after the shoes of those employed around the premises.

The air-blast main was about 15 inches in diameter. From the blowing tubs it sloped downward to the rear of the furnace, at which point an escape box was installed. This was a wooden inclosure with a door that could be opened to allow the blast to pass to the atmosphere when it was not required. In case the keeper's signals to the engineer to stop the machinery failed to have effect or, when it was desired to dispense with the blast for only a short period, the escape box could be opened by means of a lever placed within convenient reach of the keeper stationed at the front arch of the furnace.

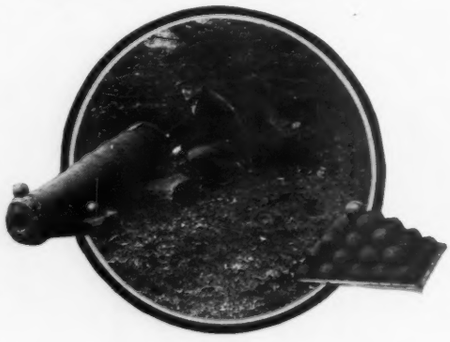
A plentiful supply of charcoal was essential to operations, and this was prepared in the surrounding woods and hauled in from points up to eighteen or twenty miles away. From ten to twelve 6-mule teams were employed in this work; and during the summer huge bins were filled to assure a store for the period when snow would prevent access to the forests. The charcoal was made in circular pits, about 30 feet deep, which held from 30 to 35 cords at a charge. Heavy pieces were put in first, followed by smaller wood and leaves. Openings to furnish air were provided at vertical intervals of 4 feet. After a pit had been filled, it was lighted and allowed to reach a high heat, after which the top was covered with clay. About fifteen days was required to reduce the charge to charcoal. During this time the air supply had to be controlled carefully, and this demanded constant attendance. Hickory was considered the best wood for charcoal, with ash and white oak next preferred.

The Cornwall Furnace cast 46 cannon for the Revolutionary War in addition to considerable shot and some stoves. If a cannon did not burst when subjected to two test shots, it was accepted by the Continental Army as satisfactory. These cannon were all delivered to Philadelphia for placing on ships. As restored, the bulletin board in the engine room bears the following chalked order which occupied that space on February 22, 1778:

> Gen'l George Washington and Gen'l Lafayette will be here on Monday to see the casting of the first cannon of his order of 24. Charge the furnace with Frog Hollow and Golden Key ore halfe and halfe. Keep blower at 9 revolutions.
>
> Peter Smaltz, Mgr.

CANNON MADE AT CORNWALL

Cannon, shot, and stoves for the Continental Army were cast at this furnace. Each cannon was tested before delivery to Philadelphia by firing two shots from it, and in recent years several of the 4-inch balls thus expelled were dug up in the meadow adjacent to the property. The cannon shown below was rejected because of imperfections, and is now on display at the entrance to the estate of Mrs. Margaret Buckingham, who has donated the Cornwall Furnace to the Pennsylvania State Historical Society.



Most of the iron made was run out through a channel in the floor and allowed to flow into sand molds. As it was impure, it was reworked in either bloomeries or chafery forges. No doubt prices varied; but, as reported by a writer in 1756, pig iron was sold at the furnaces at from £3, 6s, 8d to £3, 10s per ton—probably equivalent to from $3.50 to $4 in our money. Even at these prices, there was a profit of from $1.50 to $2 a ton. After forging, the iron increased five or six times in value.

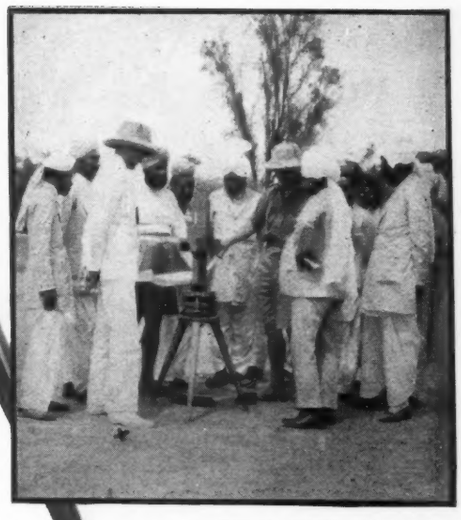
Peter Grubb, the builder of the furnace, ran it until his death in 1754, when the property fell to his two sons, Curtis and Peter, Jr. In 1786, another Peter Grubb, son of Curtis, sold a one-sixth interest to Robert Coleman, who acquired full ownership in 1803. Thereafter, until the fire died out for the last time in February of 1883, the property remained in the hands of Coleman's heirs.

William Penn and the colonial government permitted slavery until 1780, and about two dozen negroes of both sexes were maintained by the Grubbs. They served in various capacities in the household and took part in the several activities entering into iron making. Curtis and Peter Grubb, Jr., were both colonels in the Continental Army; and, following the close of hostilities, they returned with some Hessian prisoners. These were granted their liberty if they remained and worked, and many of them did.

The ore body from which the furnace received its supply has passed through many hands, and is now controlled by large steel interests. At the time Robert Coleman acquired a sixth interest in the furnace he also bought a similar share in the ore banks. In the conveyance it was stipulated by the sellers, Peter and Mary Grubb, that their heirs or assigns should have the perpetual right to mine free of charge sufficient ore to supply any one furnace of their designation. This right was sold to the Robesonia Iron Works, and the agreement is still in force.

Geophysical Prospecting—A New Science

RUSSELL C. FLEMING



THE TORSION BALANCE

The gravimetric method of geophysical prospecting calls for determining the gravitational pull of various components of the earth's crust. The instrument used is a torsion balance, so named because it balances if the pull is equal in all directions. In the center is a Suss-Rybar torsion balance set up for visual or direct reading. Considerable work with this class of apparatus has been done in India; and the picture at the right indicates the interest that the natives find in this mysterious device. Because the torsion balance is sensitive to temperature changes, it is set up in a portable house which serves as an insulating agency. Above is shown a Suss-Rybar instrument, which is made in Budapest, in use during field work in Hungary.

Photos from Donald C. Barton

GEOPHYSICAL prospecting is a science that has been developed largely during the past ten years. It may be defined as applying the laws of physics to the study of the materials and structure of the earth's crust or, more simply, as a means of learning something about the soils, ores, and rocks underground without the labor and expense of first digging a hole. There are several methods of doing this; and for every rock difference that can be made detectable at a distance, a means of receiving knowledge of that difference has been found and studied. In the case of some methods, properties or forces inherent in the rocks, themselves, are employed to obtain information, and in others force is created and sent into the earth and the effects of that force are measured. However, all may be placed in four general classes: magnetic, gravimetric, seismic, and electric or electromagnetic.

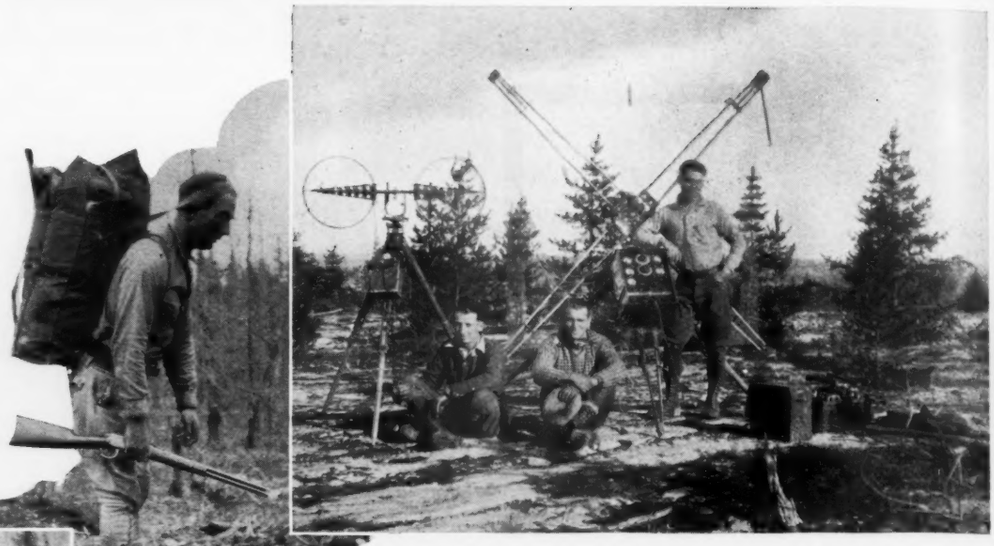
The magnetic methods are the oldest. Their use dates from the time ordinary compasses were employed to locate iron ore early in the seventeenth century, especially in Sweden. It is well known that a compass needle is affected and thrown off the true bearing near masses of magnetic iron ore—that is, the normal magnetic field of the earth is distorted near and over magnetic masses, and the compass detects this distortion. From the compass was evolved the dip needle. This was used for years in Europe and in the Lake Superior region for finding iron ore and for exploring the permanent variations of the terrestrial magnetic field. During the latter part of the nineteenth century more delicate instruments, called magnetometers, were devised to measure either the horizontal or vertical component of the earth's field, and during the past few years they have been refined so that extremely small changes in the terrestrial field can be ascertained. With the more delicate instruments it became apparent that many types of rock other than iron ore have a slight but measurable magnetic effect. Particularly is this true of igneous rocks—those that have cooled from the molten state and underlie the surface everywhere at greater or lesser depth.

The earth's magnetic field is not constant. It varies with the latitude, and it also varies daily with the temperature at any one point. When making field observations these changes must be checked at a control station and allowed for. When making a survey, readings are taken systematically throughout the area to be studied, and the corrected results are examined to find any magnetic anomalies or permanent distortions in the earth's field. When an anomaly is located it must be interpreted in terms of what has caused it. Herein lies the difficulty, because many buried formations will be shown as a magnetic anomaly at the surface and the magnetometer will reflect all these changes together for any particular area.

Wide experience and intimate knowledge of the local geology are necessary to decipher results correctly. Such a formation as a dike of igneous rock, protruding upward from a great depth through sedimentary strata, may reveal itself by a magnetic anomaly; sometimes the magnetometer will indicate changes in the contour or character of igneous rocks forming the basement under even thousands of feet of sedimentary rocks; and, again, parts of mountain ranges, buried through the ages under many strata of sedimentaries by the

SCENES IN CANADA

Much geophysical work has been done in the mining fields of Canada, and some good results have been obtained. The view below shows the operator of an inductive receiver lining up his coils with the transmitter. At the right are an inductive receiver and a transmitter loop. The latter is collapsible to facilitate its transportation. The man standing is resting his arm upon the transmitter set, and on the ground near his feet are the storage batteries which provide the operating power. In this radio-induction method, alternating current is passed through insulated wire loops at the surface and serves to set up a secondary current in the underground formations. The electromagnetic field surrounding this secondary current also induces a current, and from this knowledge is obtained of subsurface conditions. In the center is Rogers Clarke on the trail with a 139-pound pack.



Photos from Rogers Clarke

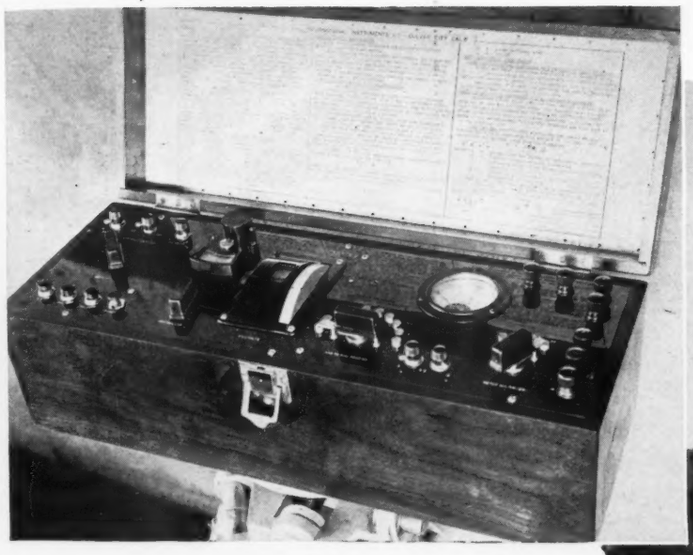
inexorable erosive forces of nature, will reflect their presence in the magnetometer readings. In the Panhandle of Texas, at the west end of the Wichita Mountains, isolated peaks protrude from the flat plains, suggesting that the mountain mass may continue westward completely covered and engulfed by later deposits. A magnetometer survey, corroborated by drilling, has shown that it does continue under the surface for more than 160 miles northwestward from the point at which it last appears above ground. This buried range, which never has been seen nor trod by man has been named the Amarillo Mountains. The determination of this fact was important geologically, because the topography of the subsurface range might have an influence on the attitude of the overlying and surrounding sedimentary beds—such as the Big Lime which, elsewhere, is valued as an oil-horizon marker—and, therefore, might be an important factor in the region in exploring for oil and gas.

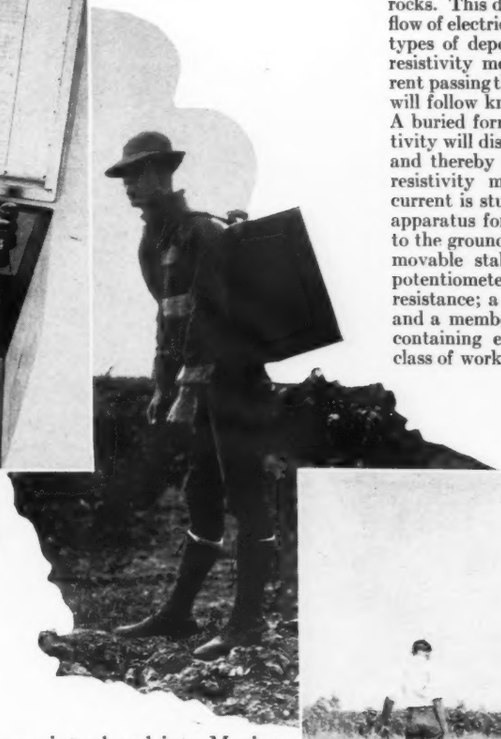
This instance illustrates the practical use of the magnetometer. Except in the case of iron ore, it does not locate the valuable deposit directly: it is able, sometimes, merely to give indication of favorable or unfavorable locations in a search. Since the instruments have been so highly refined, and methods of interpreting results are more fully understood, many surveys are conducted with practical results. Iron-ore outcrops have been traced under glacial drift; buried igneous intrusions have been determined; the extent and horizon of copper-bearing lava flows have been found; local deposits of magnetic black sand, associated with placer gold in sand and gravel, have been delineated; faults and hidden structural conditions have been located and traced. The instrument, probably because it is the cheapest and most rapid form of geophysical exploration, is becoming increasingly important as an aid to geologists and engineers who delve in the earth in solving their complicated and perplexing problems of geological structure.

Gravimetric methods of geophysical prospecting are based on determining the differing specific gravities, or heaviness per unit volume, of components of the earth's crust. Each cubic foot of the earth, or its various materials, exerts a gravitational pull which is proportional to its weight but which decreases rapidly with distance. Sir Isaac Newton, when he observed the fall of that famous apple, first perceived that the earth pulled the apple down, instead of the apple pulling the earth up, because the earth was much larger and heavier and therefore had the stronger pull. A heavy mass in the ground, such as a metalliferous ore body, will exert a stronger gravity pull than the surrounding rocks; and by recording that stronger pull the ore body can be detected. Conversely, a mass that is of lower specific gravity than the average about it also offers a problem soluble by gravity methods. The Eötvös torsion balance, named after Baron Roland von Eötvös, is the instrument primarily used for this purpose. It is called a balance because it will give no response when the gravity pull around and beneath it is uniform. Only when there is a mass of greater or lesser density than the average on one side or another of it does it become unbalanced and give a reading.

Usually a number of readings are made throughout an area, and any subterranean effect is interpreted in terms of what may have caused the unbalance. Work with the torsion balance is slow and painstaking; as it must be set up in a little portable housing to insulate it against temperature changes and must be allowed to rest for some time after each set-up to reach a state of equilibrium before a reading is taken visually or photographically. Obviously, an instrument sensitive enough to detect the minute gravity pull of a small bowlder buried in the soil nearby—something the torsion balance can do, is greatly affected by differences in the contour of the ground surface. A hill on one side of the instrument or a valley on another will have a marked effect on it, hence it must be set up in a level place and the results laboriously corrected mathematically for differences in surface elevation for a relatively great radius.

Skill and experience of a high order are required to translate the readings into the practical terms of what lies underground. Generally, several interpretations are possible, and so a series of conditions is hypothecated—each set being fitted to the balance results until one is selected that most nearly satisfies the record. Ore bodies are common in mountainous country, and it can be easily seen that the torsion balance has a limited application in searching for ore because conditions are too complex. Where salt domes, volcanic plugs, laccoliths and kindred intrusions occur in fairly homogeneous country rock, there the instrument may be capable of giving a definite solution. A salt dome is an underground geologic structure of much economic interest, as its presence may have so influenced the surrounding strata as to make the area about the flanks of the dome of importance as a potential oil pool. The torsion balance has found a suitable field in prospecting for hidden salt domes in the Gulf Coast





THE RESISTIVITY METHOD

Ore-bearing areas conduct electrical current millions of times better than ordinary rocks. This difference in resistance to the flow of electrical forces offered by different types of deposits forms the basis of the resistivity method of prospecting. Current passing through homogeneous ground will follow known and predictable paths. A buried formation of different conductivity will distort the conventional pattern and thereby reveal its presence. In the resistivity method, the distribution of current is studied by connecting suitable apparatus for measuring electrical forces to the ground through a number of short, movable stakes. These pictures show a potentiometer for measuring electrical resistance; a resistivity crew in the field; and a member of a crew bearing a case containing essential instruments for this class of work.

Photos from International Geophysics

region of the United States where conditions are favorable to its use.

Torsion balances were first brought to the United States in the latter part of 1922 by two oil companies, and the first salt dome to be located by geophysical methods was discovered in the spring of 1924 by this type of instrument. In the years 1924-26 three definite and two more possible salt domes were detected in southeast Texas and southwest Louisiana by this means, which has continued to make further discoveries. By way of contrast, only five new domes had been located there in fifteen years prior to 1924 by ordinary geological methods. In the mid-continent field and elsewhere it has been used locally with success, and it has done extensive work in Mexico. In California it has generally been found wanting because of the complex geological conditions that prevail. Faults, buried granite ridges, and other structures have been investigated and mapped by the torsion balance to some extent, but its principal application is that of checking up and detailing the findings of quicker and more expedient instruments, such as are used in the seismic method of prospecting.

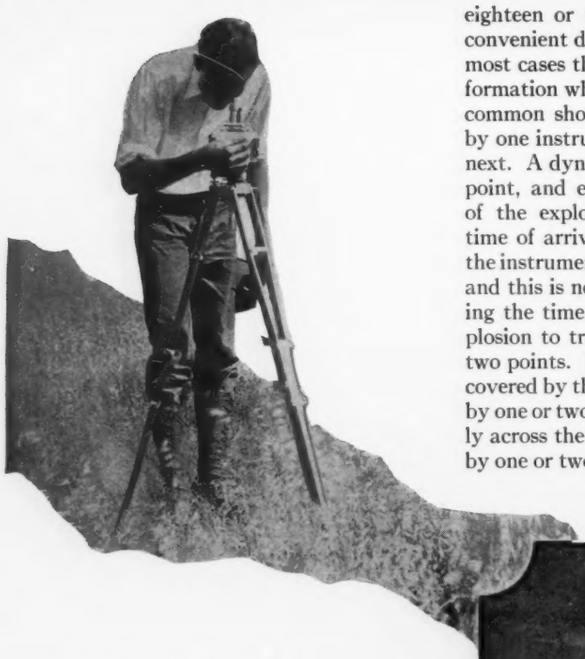
Instruments developed for the seismic method are an outgrowth of the delicate seismograph which has been employed for years in recording seismic disturbances, earthquakes. Long ago, studies of seismograph records showed that the elastic earth waves caused by an earthquake were affected by the types of strata through which they traveled, and that accurate conclusions regarding the constitution of the crust of the earth could be drawn from the manner and the speed with which the waves traveled from the center of disturbance to the recording instrument. Later, heavy charges of dynamite were set off instead of waiting for an earthquake to occur, and then the area between the point of the explosion and the observatory could be subjected to study. Years of experimentation resulted, in 1919, in extremely accurate portable instruments that could be taken to the field and employed in the investigation of local geological structures.

In 1923, successful methods, using the Mintrop instrument, were introduced into Mexico by the Royal Dutch Shell Company, and in the fall of the same year they were brought to Oklahoma and Texas by the Marland Oil Company. The following spring the method was tried in the Gulf Coast salt-dome district by a concern working for the Gulf Production Company; and the resultant discovery of a number of domes led to its widespread adoption and to the phenomenal growth and success of the seismic work. Since then, the uncanny and almost clairvoyant powers of the instruments to find possible oil structures, under proper conditions, have been demonstrated time and time again. It has been stated that the introduction of the seismic method into Texas and Louisiana has speeded up the discovery of salt domes by 75 years. From 1924 to the middle of 1928, so it has been estimated, more than 50 oil formations, mostly salt domes, had been found in this country by the seismic method. Credit for locating three of them belongs primarily to the torsion balance, but they were proven by the seismograph.

Intense rivalry developed between the various oil companies over the use of the method. Crews of one company would be followed by scouts of rival companies who would attempt to benefit by any results obtained, and the greatest speed and secrecy were therefore necessary in carrying out the work. If crews in the field halted to reshoot or to check an indication, rival companies would usually appear on the scene almost immediately unless the land was wholly owned by the company on the ground. Efforts would be made by a crew to sneak in check shots surreptitiously without seeming to pause for reshooting. Seismic work is the most expensive form of geophysical prospecting, and haste to be the first to cover untried territory made it even more so. At the height of the competition, the cost of maintaining a standard seismic crew was reported to have been in the neighborhood of $15,000 to $20,000 per month. In reconnaissance shooting of Gulf Coast salt-dome areas a crew could cover 150,000 to 300,000 acres per month.

Seismographs, like the torsion balance, have had their greatest success with simple large-scale structures, and, so far, have not been effective in searching for metalliferous deposits for the same reasons that apply to the torsion balance. That does not say, however, that with further refinements in the instruments, in technique, and in knowledge of interpretation, both methods may not become of importance in the field of ore hunting.

Seismic prospecting is based on the fundamental physical property of variation in the speed of transmission of elastic earth waves in the different geologic formations. The speed of transmission of the waves, geologically, is practically proportional to the denseness and compactness of the formation. Thus unconsolidated sands, shales, and marls transmit the waves at a low speed—that is, they are "low-speed" beds. Weak sandstones and lime-



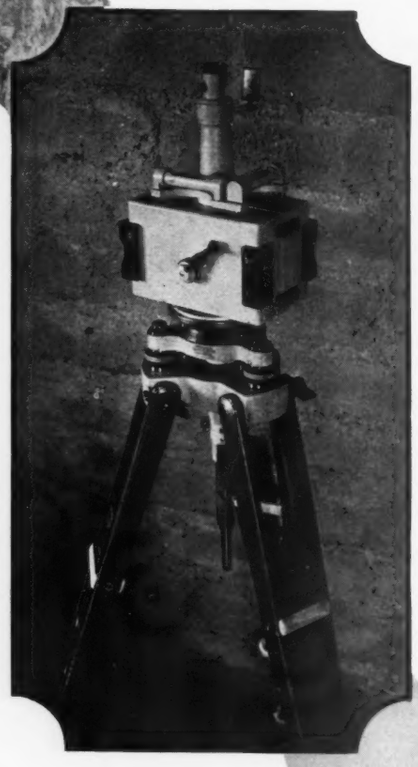
stones have slightly higher speeds, and massive crystalline rocks such as hard limestones, rock salt, schists, gneisses, and igneous rocks are "high-speed" beds. Wave velocities in the various formations range from about 1.36 miles per second in unconsolidated formations to 3.91 or more miles per second in the massive crystalline rocks. The highest-speed beds are commonly, though far from universally, deeply buried. The elastic earth waves act much as do light waves on striking glass. If, for example, a high-speed bed underlies one of lower speed, waves striking the contact will be reflected back to the surface or will be refracted along the upper surface of the high-speed bed and then re-refracted to the top of the ground. The time taken by the waves to travel from the point of explosion to the reflecting and refracting contact and back to the recording instruments indicates the type of rock through which they have passed and also reveals the presence of and some facts concerning the lower high-speed bed. In its present state of development, the seismograph is applicable only when the velocity of transmission of the waves increases progressively downward, because a massive high-speed bed will obscure everything below it if the underlying beds have a lower rate of transmission speed. Therefore, seismic prospecting cannot be used where an undesirable high-speed bed screens the sought for horizon, as in the caliche-covered area of southern and western Texas.

So-called refraction shooting was the first method to be developed and applied. As the name indicates, it is the refracted waves that are utilized, and by this means a great deal of information about the underlying beds may be obtained. If no relatively high-speed bed is present, only the direct or unrefracted wave will be received: if a high-speed mass, such as a salt dome, is present under lower-speed beds, then the position, limits, depth to the top, and form of the upper surface of the mass may be determined within certain limits of accuracy.

The usual procedure in looking for domes is to have a number of instruments, even up to eighteen or twenty, spread out fanwise at a convenient distance (say 3½ to 7 miles, and in most cases three to five times the depth of the formation which it is desired to map) from the common shot point so that the area covered by one instrument will overlap the area of the next. A dynamite charge is set off at the shot point, and each instrument records the time of the explosion causing the wave and the time of arrival of the wave. The distance of the instrument from the explosion also is noted, and this is nowadays usually done by registering the time it takes for the sound of the explosion to travel through the air between the two points. If a salt dome lies within the area covered by the instruments, the waves received by one or two of them will have traveled directly across the dome, while the waves picked up by one or two more of them will probably have gone obliquely through the dome. As the salt dome is a high-speed mass, the waves across the dome will have a higher speed than those that are normal for the rocks of the area, and the waves crossing the dome obliquely will also show a slightly higher speed. It is desirable to check any indications found with shots from another angle, provided, of course, the land is owned by the company working on it, or the scouts of rival companies can be stalemated. From 40 to 700 pounds of dynamite may be used at a shot; and commonly the charge is buried some distance—up to 20 or 25 feet—in the ground because the earth waves thus induced are far stronger than they would be if the charges were set off at the surface.

This fan type of shooting is possible only in a rapid reconnaissance for structures of the salt-dome type where the high-speed core of a dome rises thousands of feet into beds of lower velocity—that is, where the structure is extremely large and well defined, seismologically speaking. For structures in lesser relief, which are more numerous and equally if not more important, the means of identification must be modified and profiles of the areas run so that the surface of the high-speed structure may be mapped.

In 1926 was developed the reflection method, whereby the waves reflected from the upper surface of a high-speed bed underlying lower-speed beds were recorded and utilized. In this type of shooting is indicated the length of time it requires for the waves to go from the shot point to the surface of the high-speed bed and to bounce back to the instrument. The depth at which the high-speed bed lies is thus determined with each shot; and, theoretically, it is necessary only to set off a number of such shots in an area to make a contour map of the reflecting bed. This bed may not be a potential source of oil; but, provided it conforms to the oil-bearing horizon, the information so obtained is applicable to that horizon. However, in practice, the method is not so simple as it sounds—and this holds true for all geophysical methods, for unexplainable reflections are sometimes obtained, and the



OLDEST GEOPHYSICAL METHOD

Of the four principal classes of geophysical prospecting, the magnetic is the oldest and best known. It is also the most rapid and the least expensive. In its simplest form—the ordinary compass—it was first used to detect and locate Swedish iron ores. Later it became evident that many rocks, particularly those of igneous origin, also possess magnetism to a small degree, and delicate instruments have been devised to measure its effect. Notable among the accomplishments of the magnetometer was the discovery of the Amarillo Mountains, a range of hills in the Texas Panhandle that lies underneath sedimentary deposits. The pictures, which are used through the courtesy of International Geophysics, show a magnetometer at close range and two instruments of the same class in use in the field.

depth determination is not always satisfactory. The reflecting bed cannot be identified by this method alone; and beds may be "jumped" without warning—that is, in different parts of an area different beds may act as the reflecting horizon. In reflection shooting, the dynamite charges are smaller than in refraction shooting because the distances are shorter. Taken all in all, the seismograph is one of the most important aids ever developed to increase the powers of the oil geologist in his widespread and hazardous search for "black gold."

Of the geophysical methods so far discussed only the magnetic has had any extensive application to the complex and highly local problems associated with exploration for ore deposits. Metalliferous deposits are very small compared to the extravagantly large and pronounced formations investigated for oil—ore bodies a few hundred feet in greatest dimension being exceptional. The problem in searching for them is in part one of covering a small area—perhaps not more than a single mining claim—with instruments which should be able to give positive indication of the presence or absence of a looked-for deposit and distinguish it from heterogeneous rocks that are not ore bearing. Equally important, though, are methods which are of aid in delineating structures, tracing out faults and similar features, giving information about rocks known to be associated with ore, or outlining structures which might have an influence on the deposition of ore—in general, broadening the knowledge of the mining engineer and geologist concerning the local geological conditions and giving him clues to the possible location of valuable deposits.

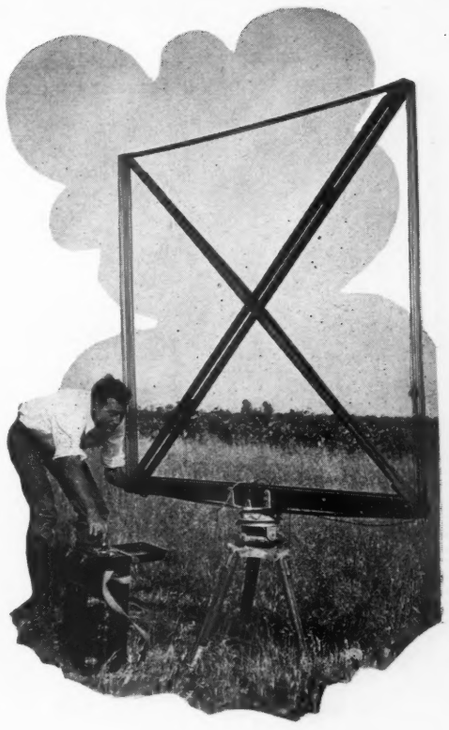
Electrical methods of prospecting are of most importance in this branch of the work. Numerous electrical instruments are available. Some of these differ from others only in detail, but all fall into a few general classes. Lack of space does not permit more than a brief description of the instruments, representative of each type, which have had practical application in the field. Because some are not touched on here, it should not be inferred that they are not of scientific interest and value because, in a brief and nontechnical discussion such as this, theory and practice necessarily must be presented sketchily. In the field, expected and unexpected difficulties are encountered with all methods, and the problems are so many and so varied that any one type has application only where conditions are suitable. With increasing knowledge, the scope of the instruments has been growing rapidly during the past few years, but more and more it is understood that the results of one method should be checked against those of another or others before drawing positive conclusions. Some of the instruments are patented and are zealously guarded to keep them secret.

There is but one electrical-prospecting method that does not require an ore body to be artificially excited to obtain evidence of its presence. That is the self-potential method. Ore bodies in the ground, particularly sulphide minerals, are continually undergoing natural oxidation, and the upper zones are in a state of activity differing from that of the lower zones. This electrochemical activity results in a flow of electric current through the ground tending to neutralize the difference of potential set-up. In other words, the ore body acts as a large electric cell; and when this activity is sufficiently pronounced, a current flow is maintained in the rock surrounding and between different parts of the ore body. By tracing on the surface of the ground the paths of these currents it should be possible to find the ore body causing them. The instrument designed to do this is a potentiometer—an apparatus for measuring potential—connected by wires to two nonpolarizing electrodes by means of which contact is made with the ground. The area under consideration is surveyed with the instrument to show how the current is distributed at the surface either by delineating and following lines of equal potential, or by outlining the potential gradient. If an active ore body is present it will be disclosed by a negative center of current flow.

Vigorous chemical activity is essential to the generation of earth currents of sufficient magnitude for this kind of survey; and the method proves effective only with mineral deposits which readily undergo oxidation—such as those containing quantities of pyritic sulphide, and only when the upper limits of the ore zone extend close enough to the surface to be affected actively by oxidizing agencies. Thus this method is confined largely to the locating of ores high in pyrite or iron sulphide, and even then particular circumstances may preclude discovery.

All the other electrical methods use a system whereby an artificial force or field is created in the ore body, if present, and the effects of that field are measured. All are based on the principle that rocks, ores, and soils act as electrical conductors with differing degrees of conductivity, or that they have varying degrees of resistivity (specific resistance to the passage of an electric current). Different rocks vary widely in conductivity or resistivity. Ore-bearing rocks may conduct an electric current several million times better than surrounding country rocks. Loosely consolidated materials such as sand and gravel, saturated with moisture, may conduct a current some thousand or hundreds of thousand times better than massive well-indurated rocks. Use is made of this principle in various ways.

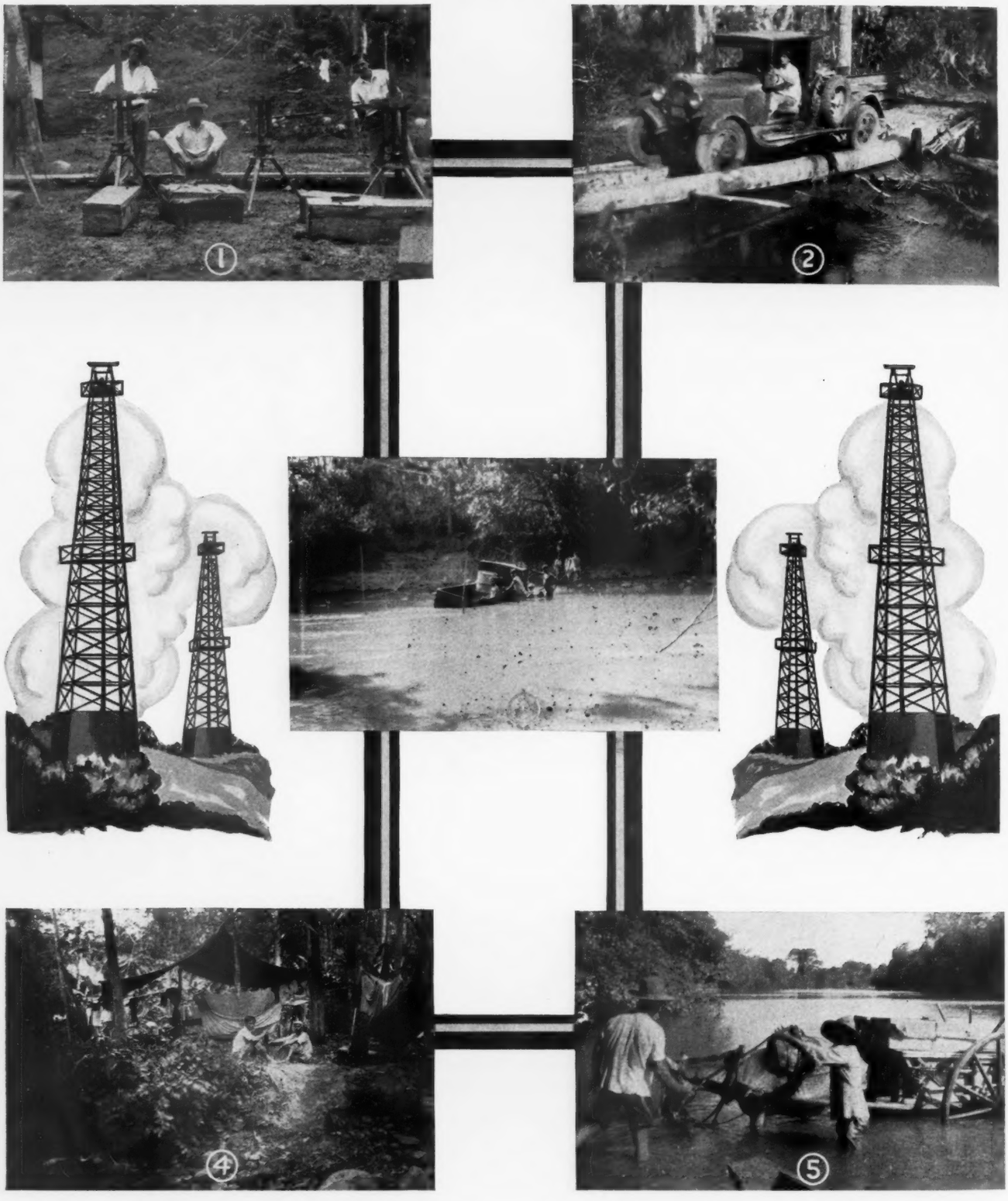
Only four of the methods by which the effects of a created field are measured will be taken up here. Two of them may be classed as surface-potential methods, namely, the equipotential-line method and the resistivity method. These measure the distribution or force of a current passed through the ground, from which inferences can be drawn as to the type of rock the current has encountered. Two other means are based on the determination of magnetic fields set up in the earth by alternating current and measuring the effect of an ore body, if present, on these fields, which may be produced either by passing a current through an insulated cable laid about the area or by using a small loop and radio transmitter—in short, the radio method.



RADIO RECEIVER AND TRANSMITTER

The transmitting and receiving coils used in the radio-induction method must be kept in a given relation to one another—their transverse axes should be maintained in line. In the picture above, the operator is lining up the transmitting coil. In the lower, a reading is being taken at the receiving loop with the aid of earphones. The radio method will detect highly conductive material lying below the area being studied. Since worthless iron pyrite is as highly conductive as valuable ores, the results can be accepted only as "electrical indications," and the actual character of the deposit that is detected must be ascertained by underground exploration. Geophysical prospecting does, however, serve to prevent useless digging by revealing areas that contain no minerals.

Photos from J. J. Jakosky



Photos from Homer Gilmore

CAMERA RECORDS OF A GEOPHYSICAL CREW IN VENEZUELA

The geophysicist is always well versed in geology, and frequently he is also a mining engineer or a petroleum engineer. Aside from thorough academic training, he must also have a hardy physique, for most of his work is done in the byways that have been little or not at all trod by civilization. The pictures on this page indicate the difficulties that often beset a crew in the field. This particular expedition sought evidence in a Venezuelan jungle of geological conditions favorable to the occurrence of oil. The work was carried on with torsion balances.

No. 1 shows three of the crew cleaning their instruments after having used them in the field. In No. 2 a truck bearing torsion balances is shown crossing a rude log bridge constructed by the crew across a stream in wild country. Food and supplies were important considerations, and their procuring called for hard work and ingenuity. The center view depicts the difficulties continually met by the supply truck. No. 4 gives a glimpse of one of the camps of the crew in the interior of a densely grown section. A native ferry is pictured in No. 5. The cart contains the expensive and delicate instruments which must be handled with care regardless of the physical conditions encountered.

WINTER WORK

In Canada, geophysical work is usually done during cold weather because summer operations are difficult on account of swamps, muskeg, and heavy timber; prevalence of black flies and other insects; and limited visibility. Sometimes the winter work is done in from 4 to 8 feet of snow, in which case the crew takes to snowshoes. The pictures illustrate radio-receiving sets used with the inductive method of geophysics.

Photos from Rogers Clark

The equipotential-line system is somewhat similar to the self-potential method last discussed except that, instead of measuring natural earth currents, a direct or alternating current is passed through the ground and the distribution of the current flow is studied. Two bare cables or two rows of electrodes are laid out in straight lines, one on each side of the area to be studied, and current is passed through the ground from one cable or row to the other. If the ground between is electrically homogeneous—that is, has no unduly conductive zones—the current will flow in straight lines from one side to the other. If, however, an ore body is present, with conductivity greater than the surrounding rocks, then the current flow will tend to concentrate in and pass through the conductive body, distorting the lines of flow. By tracing out lines of equipotential on the surface, or obtaining the potential gradient, as in the self-potential method, any areas of current concentration, and, therefore, any conductive bodies, will be delineated. Either direct or alternating current may be used; but for practical reasons alternating current is employed almost exclusively.

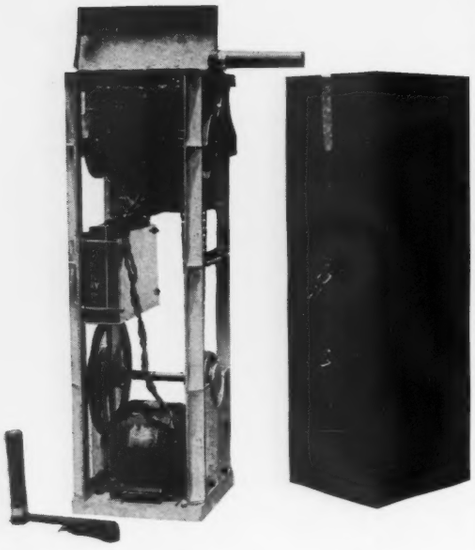
Resistivity methods of prospecting are based on the resistivity of various rocks rather than on their conductivity. They have been developed and applied not only for identifying highly conductive ore bodies but also for structural investigations of many kinds, and give evidence of being the most adaptable and universal of all the electrical methods. The earliest work of this kind consisted of studying the resistance to a current passed between a pair of electrodes a fixed distance apart. That process, however, was abandoned because the resistance values were determined almost solely by the nature of the contacts the electrodes made with the ground. Rooney and Gish, of the Carnegie Institution in Washington, C. and M. Schlumberger in Paris, and Professor Koenigsberger of the Freiburg University, looked into the problem and invented improved means. The Rooney-Gish 4-electrode apparatus can be used to determine the resistivity values of the rocks under any given point.

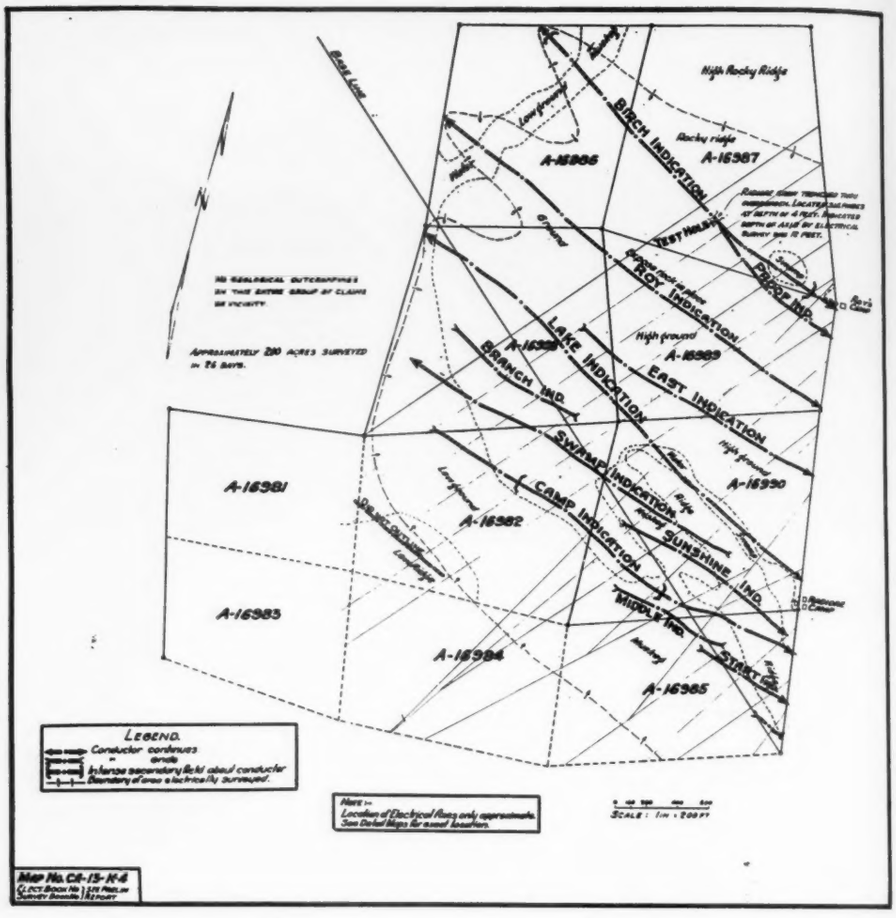
In the case of the method as developed by them, and of which there are now several variations, the earth is assumed to be a semi-infinite homogeneous conductor, and observations are taken to detect any departures from this assumption—that is, an effort is made to locate any bodies or beds of greater or lesser conductivity than the surrounding medium. Current is passed through the earth by means of two electrodes driven into the ground, and two more electrodes are placed between and in line with them a predetermined distance apart. By measuring the amount of current (amperage) passed into the ground through the two outer electrodes, as well as the voltage (difference in potential) between the two inner electrodes caused by that current, a measure of the resistance met by the current in passing through the ground may be had. This resistance determination may be taken as referring to the block of ground between the two potential electrodes that has an average depth equal to the electrode separation. In other words, with any given electrode separation, the average depth to which the current penetrates may be assumed to be equal to one-third of the distance between the two outer electrodes.

Starting with the electrodes close together, and increasing the separation by steps, it is possible to ascertain the average resistance (or, by calculation, the specific resistance or resistivity) at greater and greater depths, and from these resistivity measurements can be drawn conclusions concerning the formations under the measuring point. The information obtained is, in effect, the specific resistance, at definite depth intervals, of a column of rock extending straight down from the measuring point. The two outer electrodes are connected in series with an ammeter and a source of current, batteries, and the two inner electrodes are joined to a potentiometer. In the Rooney-Gish apparatus the current is alternated before being passed into the ground, and that part returning through the two inner electrodes is changed back to direct current by means of a small hand-driven commutator so as to eliminate natural ground currents from the potential measurement. These ground currents are considerable in places, and would overshadow the applied current if they were not eliminated in some manner.

With the exception of the metallic sulphides, which generally possess conductivity to a marked degree, the electrical conductivity of rocks is purely electrolytic—caused by moisture content—and disappears when they are entirely dry. The resistivity of most rocks is inversely proportional to the amount of contained water when the water carries ionized salts in solution in considerable quantities, as most earth waters do. The resistivity of rocks varies from a few thousand ohms per centimeter—centimeter square for most metallic minerals—to 500,000 or more ohms per centimeter—centimeter square for highly resistant rocks. Gravels or soils commonly contain more moisture than do hard massive rocks, such as igneous formations, and have a lower resistivity unless other factors change the relationship.

By this method, areas have been examined for ore bodies; faults and structural features have been traced; dam sites have been studied for hidden structural defects; depth to bedrock under sand and gravel deposits, placers, etc., has been found; and many other similar problems, where depths were not too great, have been solved. In 1928, difficulties were encountered in driving the Bridge River railroad tunnel in British Columbia. Before relocating the tunnel and starting anew, a resistivity profile of the proposed course was made, and this checked remarkably well with actual conditions found when the second tunnel was advanced along the line of the profile. A resistivity survey was carried out in 1929 at a dam site on the St. Lawrence River near Morrisburg, Ont., to determine bedrock conditions and to orient exploration by drilling. The electrical measurements were checked by the drilling and showed only minor errors. Near Masson, Que., on the Lievre River, resistivity measurements were taken to find out where a tunnel could be run so that it would be in solid rock. On the results of the survey depended not only the placing of the tunnel but also the construction of a projected dam. The results showed that the tunnel would be in solid rock, and the work proceeded as planned. In constructing the aqueduct of the Metropolitan Water District from the Colorado River to the Los Angeles area almost





SURVEY RESULTS PORTRAYED GRAPHICALLY

At the right is a map of a 200-acre tract in Canada as indicated by inductive geophysical tests. The heavy lines are the "electrical indications" which were discovered. Note that all of them have the same directional trend. This work was done by the Radiore Company, of Los Angeles, which supplied the illustrations shown here. Above is a hand-driven generator such as is used to supply current for an inductive transmitter.

a hundred miles of tunnel will ultimately have to be driven. The proposed course of the tunnels was first checked by resistivity survey to find out what conditions would be encountered underground. These are only a few of the many instances that might be cited of the work done by resistivity methods, aside from the numerous surveys for ore bodies that have been thus made. In fact, geophysical methods of prospecting, in advance of explorations by other means, should be seriously considered wherever knowledge of the subsurface is needed in engineering or mining projects.

Two more electrical methods remain to be described. By these the current is not passed into the ground by direct contact; but, instead, a magnetic field is employed to induce a current in the ground, according to the well-known laws governing alternating current. If a conductive body lies in the ground where it can be affected by this primary field, a current will be induced in that body. The induced current, in turn, sets up a secondary magnetic field of its own and influences the first or primary field. A study of these fields with proper instruments will give knowledge of the underground conditions acting upon them.

In the case of one method, an insulated copper cable is laid about the area to be investigated in the form of a rectangle which may be as much as 1x½ mile in dimensions. Current is made to flow through this cable from an alternating-current source with frequencies ranging from 100 to 500 cycles per second—up to 10,000 cycles having been tried. The resulting electromagnetic field is investigated with an apparatus consisting of several hundred turns of copper wire connected to an instrument for measuring the electromotive force induced in the search coil by the primary field and by any secondary field resulting from a conductive area in the ground. A conductive ore body can be discovered by this means, or depths to various subsurface conducting layers determined. Readings have been obtained to a depth of 1,500 feet. The method has been used in finding details of salt domes and faults near them, and in studying underground structures of various kinds.

Lastly we come to the so-called radio method. The electromagnetic field of a high-frequency current is, in effect, broadcasted into the ground from an energizing loop and radio transmitter on a tripod. Frequencies, ranging from 500 to 80,000 cycles per second, may be employed, depending on conditions, and current for the transmitter may be produced by a hand-driven geared generator. As before, if a conductive body is in the ground, this primary field will induce a current flow in the body, and that current flow, in turn, will have a secondary field. The search equipment of one such instrument, which has had wide commercial application, consists of a small receiving loop and radio amplifier, powered by batteries, mounted on a tripod so that it can be moved about and set up easily. The operator has a pair of earphones plugged into the amplifier to hear the signals received. In operation, the two coils are kept in constant relation to one another wherever the receiving coil may be placed—that is, the transverse axes of the two coils are kept in line and pointing toward each other, but the receiving loop is free to turn about that transverse axis. In a homogeneous medium, then, the weakest signal from the transmitter will be received when the receiving coil is turned so that it is flat with the ground and the normal axis is pointing straight up and down. However, when there is a conductive body in the ground to one side of the receiving coil, the secondary field from it will influence the primary field and the minimum signal will be heard in the earphones when the receiving coil is turned at an angle from the flat—when the normal axis is pointing approximately toward the source of the secondary field. A number of observations from different points with the receiving loop should outline the upper axis of the conductive body and give the depth to the top of it.

This as well as some of the other electrical methods will outline a stringer of pyrite, or other highly conductive but worthless material, as effectively as it will a valuable ore body, and therefore the results can be looked upon only as electrical indications which must be proved by underground exploration. The electrical methods principally used in discovering highly conductive zones have a limited field, for while many minerals commonly occur as conductive sulphides, others occur as oxides, carbonates,

A GEOPHYSICAL EXPEDITION IN INDIA

Following the death of Baron von Eötvös, in 1919, a geophysical institute bearing his name was founded in Budapest for the purpose of continuing his scientific researches both in the field and in the laboratory. This institute conducted an expedition into Upper Assam in India. On that occasion elephants served as burden bearers, as illustrated. In the right-hand picture the animals are obligingly kneeling to permit the observation huts to be removed from their backs.

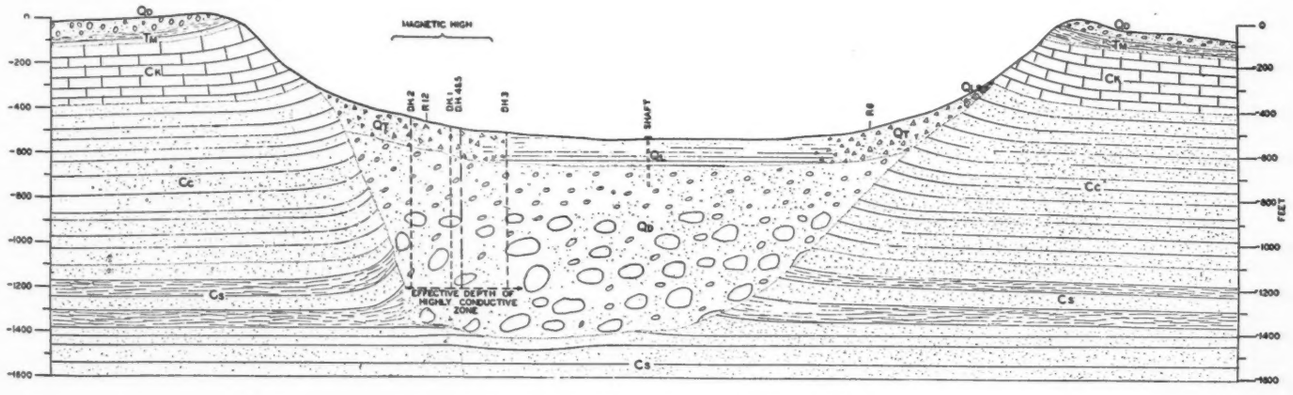
or in other chemical forms which are not good conductors. The latter will give no indication of their presence by these means, except possibly under some unusual circumstances. At times, too, the valuable material will be so sparsely distributed throughout the rock that the mass, as a whole, will be no more and no less a conductor than the surrounding barren rock. A fairly high-grade gold ore, for instance, with a value of $20 a ton at the normal price for gold, has but one little ounce of gold in a ton of material, and that is not enough to make the gold ore any more responsive electrically than the barren rock. But if the gold is known to be associated with sulphide minerals, as it frequently is, then there is a basis for discovery by electrical means.

In placer mining, resistivity work may outline the depth and contour of the bedrock under the gravels but, unless the gold of the deposit is definitely associated with magnetic black sand, no method except actual mining or sampling will reveal where or how much gold is contained in the deposit. An experienced field man frequently can distinguish indications of valuable material from those of secondary importance by the manner in which the apparatus responds and by a detailed study of geological conditions. In fact, geophysical equipment often is of more aid in helping to decipher obscure geological relationships than it is in giving direct evidence of the presence or absence of the sought-for mineral.

Many factors affect the depth to which electrical methods can be applied practically. To be detected by the instruments as now developed, the greatest dimension of a conductive body must, roughly, be comparable to the depth to the top of it. The shape, attitude, and conductivity of a body—whether it is round or flat, vertical or horizontal, influence this ratio somewhat. A conductivity ratio of several millions to one between an ore body and the inclosing rock will render a smaller body more readily detectable than will lesser ratios. In general, the uppermost surface of most metallic-mineral deposits that have been found by electric methods is 250 feet or less below ground. Sometimes depths of 500 or 600 feet have been reached successfully, and in very exceptional cases more. In France, telegraph lines have been utilized to put current into the ground at points sufficiently separated to give resistivity readings to a depth of 75 miles, but in ordinary work from 1,600 to 1,800 feet is probably the economic limit.

In spite of their limitations, notable mineral discoveries have been made in all parts of the world with these electrical instruments, and in innumerable cases they have aided in solving geological problems. In the hands of those most skilled in their use and experienced in interpretation, amazing results are being obtained; and as knowledge increases they will become even more important tools in the hands of scientists, geologists, and engineers who need to learn the truth about the make-up of the crust of this spinning globe of ours.

The writer acknowledges his indebtedness to the many authors who have contributed papers on geophysical prospecting to the American Institute of Mining and Metallurgical Engineers, as well as to other sources



LOOKING INTO A METEOR CRATER

The Arizona Meteor Crater, which was described in our May and June, 1929, issues, was for a long time an enigma to mining men seeking to locate and to recover the metals which they believed were buried there. The crater, near Winslow, is an elliptical pit some three-fourths of a mile long and 600 feet deep. Various drilling efforts failed to find the buried meteor; but a geophysical survey using electrical and magnetic methods determined that it had come to rest at one side of the opening and some 680 feet underground. Two drill holes, subsequently put down, verified this finding. The sketch, which originally appeared in a publication of the American Institute of Mining and Metallurgical Engineers, shows a probable cross section of the crater as the hidden areas were interpreted by the geophysicists. A shaft, indicated near the center, had previously been sunk without success.

Compressed Air Helps Perpetuate an Old Custom

WHERE MEMORIALS ARE MADE

The office and display rooms of Joseph Bermel Incorporated at Middle Village, N. Y. Stones from every corner of the earth are here worked into the special forms required for memorials of various kinds and also given suitable designs. The inset shows a part of the stoneworking yard.

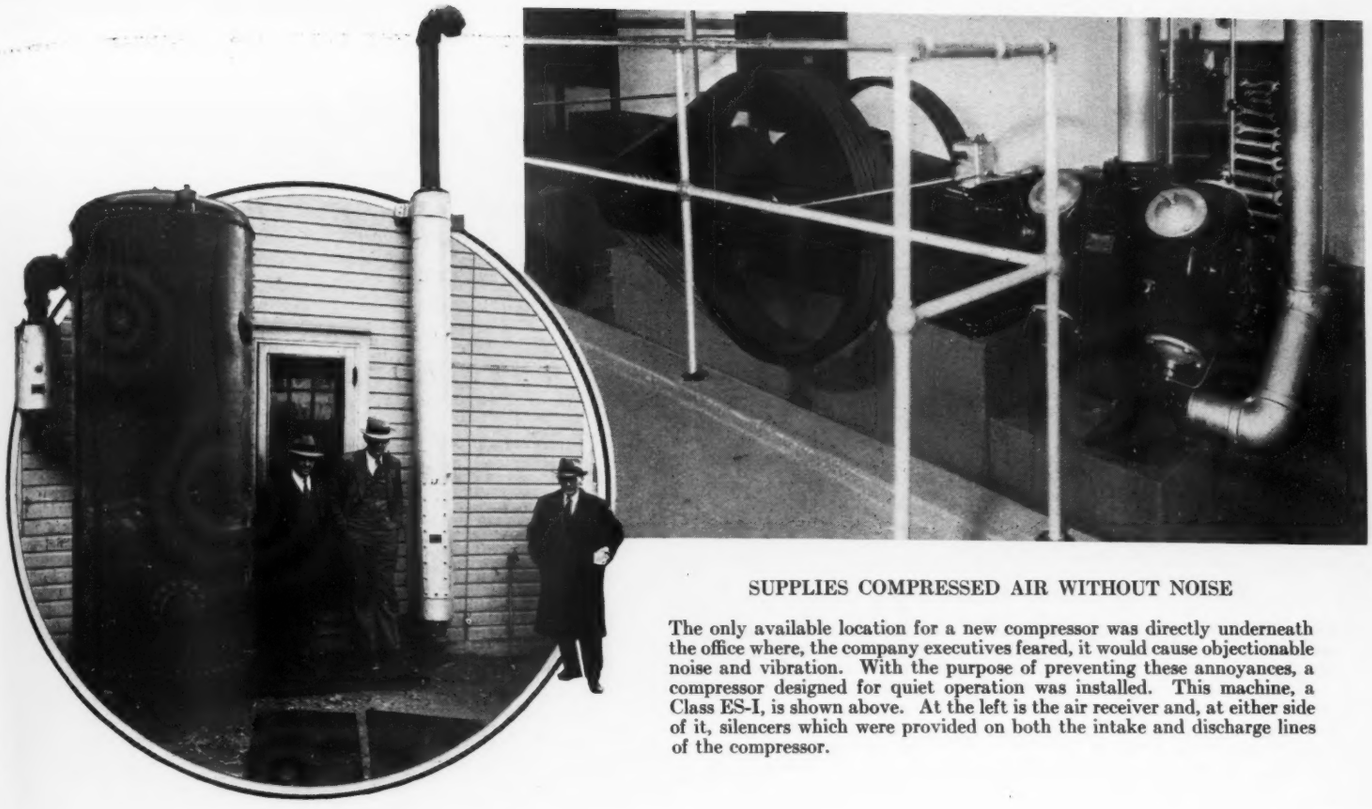
AMONG the customs that have survived since ancient times is that of erecting stone monuments. The practice, in well-nigh all countries, may be traced to the remotest periods of which evidence remains. Refinements have come with the passing centuries, but the fundamental form and principle of these memorials have changed but little. Former civilizations set up stones to observe the accession of a king or a chieftain to rulership, to mark graves and boundary lines, and to commemorate battles. As they did not know how to cut images out of rock, they had no statuary, but used the stones in their rough, unhewn form.

In virtually every part of Europe and Asia, specimens of these early monuments exist today. Inasmuch as conquering armies usually laid waste all such structures upon invading enemy territory, the survival of so many of them would seem to indicate that their number must have been very great. Primitive stone monuments are of four general types. Individual stones set on end are called menhirs. In France, alone, more than 1,600 of these monoliths have been found. One of them, now fallen and broken into four pieces, was originally an obelisk 67 feet high and weighing about 342 tons. It was made of granite, which does not occur near the site, proving that in some manner it was transported a considerable distance.

These menhirs were set up singly or in groups of from two to a dozen and more. Rows of them are now known as alignments. Numerous fine examples of this type still exist near Carnac in France. Although, today, there are gaps in some of these lines, it is believed that they once extended unbrokenly for more than two miles. A group of menhirs placed so as to inclose an area—whether circular, oval, or irregular in form—is designated a cromlech; but when close enough together to permit being roofed over by one or more capstones, then the resulting structure is a dolmen. There is evidence that dolmens were used at times as burial vaults; and they may, accordingly, be considered the forerunners of our modern mausoleums.

With the passing ages, tools of metal became available, and the art of hewing stone into various shapes and of carving characters in it was introduced. From that time on down to the present, the history of memorials parallels the growth of sculptural skill. Today, large stoneworking establishments in different parts of the world fashion monuments of every size and description. Grave markers, ranging from simple headstones to elaborate compositions, form the largest share of their business; but their products include every conceivable kind of monumental work.

Although the individual skill of the stoneworker probably can never be entirely supplanted, mechanical equipment has assumed an important place in the making of monuments. Compressed air is finding an ever-widening application in the industry, especially in operating tools which, although still guided



SUPPLIES COMPRESSED AIR WITHOUT NOISE

The only available location for a new compressor was directly underneath the office where, the company executives feared, it would cause objectionable noise and vibration. With the purpose of preventing these annoyances, a compressor designed for quiet operation was installed. This machine, a Class ES-I, is shown above. At the left is the air receiver and, at either side of it, silencers which were provided on both the intake and discharge lines of the compressor.

by human hands, lighten the labor of the artisan and enable him to increase his output many fold.

As is but natural, monument works are centered in the more populous areas, and some of the largest and best-known firms are found in the New York City district. Among these is Joseph Bermel Incorporated, which is located at Middle Village, Long Island, convenient to a number of cemeteries. The company has been in business 52 years. In addition to private and public monuments and memorials of various kinds, it constructs mausoleums complete with the inside stonework such as altars, vaults, and decorative features. Granite is used for the exteriors of all such structures, while all interior work is done in marble.

Monuments are shipped from Middle Village to all sections of the United States and, occasionally, to Mexico. Some of the finest civic and private memorials in the East were produced there. The plant is equipped to handle stones of all sizes up to the largest normally required. In some cases monuments are 6 or 7 tons in weight, while some of the mausoleums which have been built by Joseph Bermel Incorporated contain individual stones weighing as much as 15 to 20 tons.

Most of the granite used is quarried at Westerly, R. I., and some of it comes from Barre, Vt. A considerable amount of stone is imported, usually for sentimental reasons on the part of customers; and the quarries of substantially every stone-producing nation contribute material at one time or another.

As in all other classes of creative artistry, the work done cannot be measured by size alone. Small pieces are often more expensive than large ones. Manufacturing costs are largely governed by the correctness of the proportions and by the adaptability of a design to the kind of stone in which it is desired to have it executed.

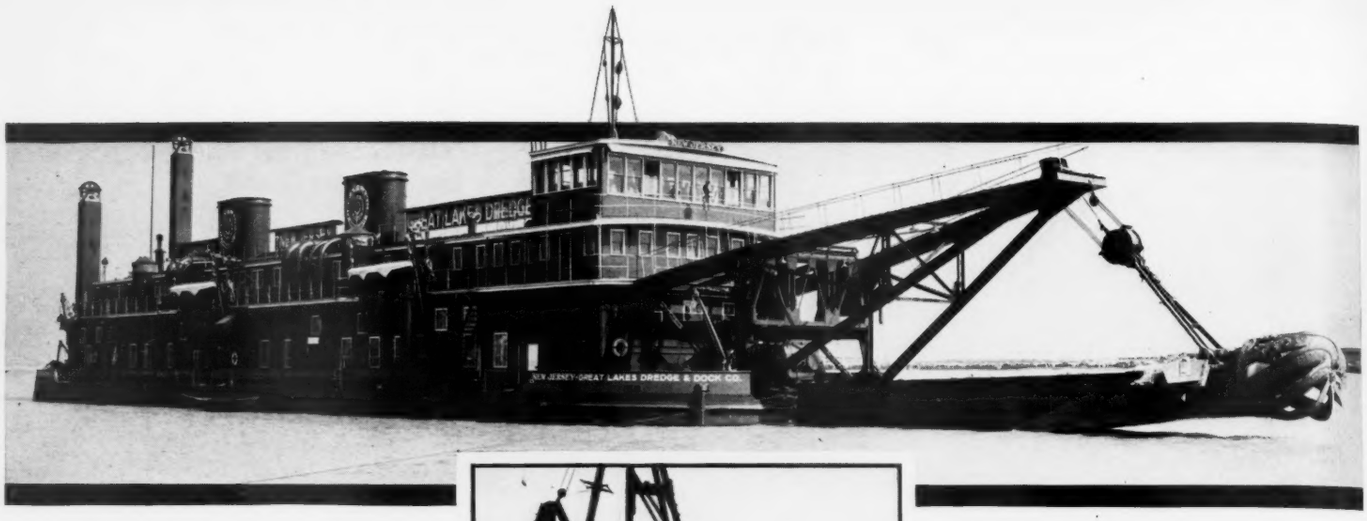
A firm that undertakes to make memorials of all sorts and sizes must be a well-rounded one with respect both to personnel and to equipment. The creation of diversified memorial designs requires the talents of a directing architect who is well versed in artistic expression. The actual reproduction of these designs calls for the touch of skilled artisans. The erection of the completed work demands the careful attention of specially trained men. It has been the endeavor of Joseph Bermel Incorporated to maintain an organization that is thoroughly qualified to carry out every detail entering into the visualizing and the executing of memorials of every class and description. It goes without saying, therefore, that, in addition to offering expert planning counsel, it provides all the human and mechanical resources essential to the numerous operations involved in preparing and setting up its products.

The plant is adequately outfitted for the handling of small and large blocks of stone and for working them into the desired forms with the utmost dispatch consistent with flawless execution. To a surprising degree it has been able to adapt air-operated tools to delicate and oftentimes intricate sculpturing, always, of course, under the trained and unerring control of expert hands. The sand blast has become an indispensable factor in this work. Ninety per cent of the decorative carving and 95 per cent of the lettering are now done by this means. The company was the first of its kind in the New York City area to install sand-blast equipment, and during the intervening years of experience it has continually aimed to widen its scope of usefulness.

Because of this ever-increasing importance of compressed air, the firm recently found it advisable to improve its compressor plant. In order to conserve space in the shops and also to insure clean intake air, it was desirable to isolate the air-producing plant from the stoneworking area. The only available site was directly underneath the office. There was some apprehension on the part of the officials that a compressor located there might be objectionable from the standpoint of noise and vibration; and in selecting new equipment special emphasis was laid on quiet operation. Thanks to the advances that have been made in compressor design, it was possible to secure a machine which satisfied this requirement without any sacrifice in economy or efficiency.

The compressor chosen was an Ingersoll-Rand Class ES-1 unit which is driven by V-belts from a 60-hp. motor. This machine has one 12x11-inch compressing cylinder whose piston displacement is 426 cfm. Owing to the quiet running of its valves and other parts, and the well-balanced design throughout, the unit operates with a total absence of annoying noise and vibration. This new compressor replaces two smaller machines of the same make that had supplied the plant with air for the past eighteen years. The latter were still in good condition when they were taken out of service.

At Middle Village, where all its stonework is done, and at Flushing, also on Long Island, Joseph Bermel Incorporated maintains sales and display rooms.



A MECHANICAL MONSTER THAT FEEDS UPON SEA FLOORS

The *New Jersey* is the most powerful dredge of its type yet built. Within its 245-foot hull are four diesel engines that generate 4,000 hp. for driving the various motors. Its keen-edged, many-bladed cutter, shown here above water, is driven by a 600 hp. motor. This dredge played an important part in creating a large part of the site for the Century of Progress Exposition in Chicago. Dredges of this type suck up bottom material with great quantities of water and pump it through pipe lines to disposal areas. The large ones handle up to 40,000 gpm. The discharge end of a pipe line is shown at the left.

Man-Made Wonders from Sea Waste

B. G. HINDES* and J. K. NOVINS

HUNDREDS of miles of smooth-surfaced highways, some of our finest airports, and extensive tracts of land on which stand business buildings, apartment houses, or manufacturing plants, have been literally lifted from the bottoms of rivers, canals, or seas. Through the medium of dredging engineering, magic carpets of earth are laid with materials elevated through 60 or 70 feet of water and transported several miles.

Like some prehistoric monster the giant suction dredge, which has made these and similar accomplishments possible, prowls about the rivers and harbors and feeds upon the sediment that forms their floors. Given the time, some of these mechanical giants have the power to move submerged mountains; and skillful transplanting of the murky waste they disgorge creates thousands of acres of substantial and useful land. Through their collective activity, many changes have been made in our marine landscapes, and still greater transformations are to come. The muck that these dredges suck from beneath the water is fairly catapulted through pipe lines laid in many fathoms of sea water, over hills, or even through city streets.

Dredging operations now in progress or projected as parts of public-works and waterway-improvement programs involve expenditures of more than $1,000,000,000, and have for their primary purpose the deepening of some 200 harbors, nearly 300 river channels, and 50 canals.

Probably few among the millions of persons that attended the Century of Progress Exposition, at Chicago, realized that they were walking upon made land. Yet the fact is that many of the buildings were reared upon ground which only two or three years ago was submerged as much as 60 feet below the surface of Lake Michigan. This ground forms a part of five strips of land, ranging from 70 to 300 acres in area, which was brought up through the water at a cost of $200,000,000. When the undertaking is completed it will have added considerably to the width of more than six miles of Chicago's lakefront. The land will ultimately be used chiefly for industrial and recreational purposes. This vast dredging program has a twofold object: that of deepening the Chicago River to permit its navigation by large vessels, and that of relandscaping the waterfront.

The *New Jersey*, one of five powerful dredges employed on this job, marks the apex in the development of mechanical mud-eating monsters. Constructed at a cost of $1,500,000, and equipped with a ladder that permits it to work in water as deep as 60 feet, the *New Jersey* has built up as much as fifteen acres of ground a month with material conveyed through a pipe line nearly a mile long. With a fleet of dredges of this capacity, a fair-sized town could be moved in a short time.

In 1915, San Francisco likewise built its exposition on land which had been reclaimed from the sea by suction dredges. A measurable portion of this coast city's residential section and most of its industrial area occupy made ground having an aggregate value of billions of dollars.

Dredging operations have increased greatly in importance and scope during recent years. The most notable advance has been in the field of dredging harbors and channels to link inland cities with navigable waterways. Much of the rapid growth of Los Angeles is attributable to its virtually man-made harbor. The dredging of a 35-foot channel in the Columbia River has made it possible for large ocean-going vessels to ascend that stream 100 miles to land-locked Portland, Ore. A similar project that was completed not long ago at a cost of $2,500,000 has turned Stockton, one of California's inland cities, into a seaport. Probably the largest dredging undertaking of this decade is that now in progress in connection with the Atlantic Intercoastal Deep Waterway which will enable small craft to go from Boston, Mass., to Corpus Christi, Tex., without venturing far out to sea. In effect, a canal is being created along the ocean shore.

One of the important present-day uses being made of the millions of tons of waste material dredged from rivers and harbors is in the construction of airports. Ten years ago, when aviation was just beginning to develop, many communities wondered how they could provide convenient landing fields. Portland, Ore., was pondering this question when an enterprising dredging engineer supplied the answer. Down the Willamette River, only a mile and a half from the center of the city, the Port Commission had been dredging out the shallow flats of Swan Island to remove perils to navigation.

*Secretary, San Francisco Bridge Company.

TYPICAL DREDGING PROJECTS

It is proposed to fill in shoals in San Francisco Bay with material excavated from the footings for the Transbay Bridge piers and to create an airport convenient to both San Francisco and Oakland. This project, which is estimated to cost $1,000,000, is sponsored by the San Francisco Junior Chamber of Commerce. The bottom picture shows how it will appear when completed. Portland, Ore., built an accessible airport in the Willamette River by means of dredging. In the center the site is shown in the making, with dredge pipes still discharging into the area. Seeking a convenient location for its new auditorium, Long Beach, Calif., filled in a site on the ocean front with material dredged from the bottom. The plot surrounded by water on three sides and protected by a semicircular pier is illustrated at the right.

Some of the material thus secured was being employed to build up worthless strips of low land so as to make them usable for industrial purposes; but there was a surplus of clay and sand, and this the commission had intended to dump into deep water. Instead, more than 30,000,000 cubic yards of material was spread out over low lying ground, and the contemplated airport-site expenditures of $1,000,000 were rendered unnecessary. Planes now taxi on a runway more than a mile long; and the airport is connected with the business section of the city by a strip of land also composed of dredged material.

Other cities are also getting their airports dirt cheap as by-products of channel-deepening, flood control, or bridge-building projects. San Diego obtained its fine Lindbergh Field by using sea-bottom sediment; and well-nigh all the landing fields along the central California coast were once tideland. New Orleans is dredging an island from the Gulf of Mexico for its airport; and San Francisco will receive a splendid aviation base in connection with the construction of the bridge across the bay to Oakland. Debris excavated from sites for some of the pier foundations is being utilized to fill in shoals to the north of Buena Yerba or Goat Island and at a point convenient to both San Francisco and Oakland.

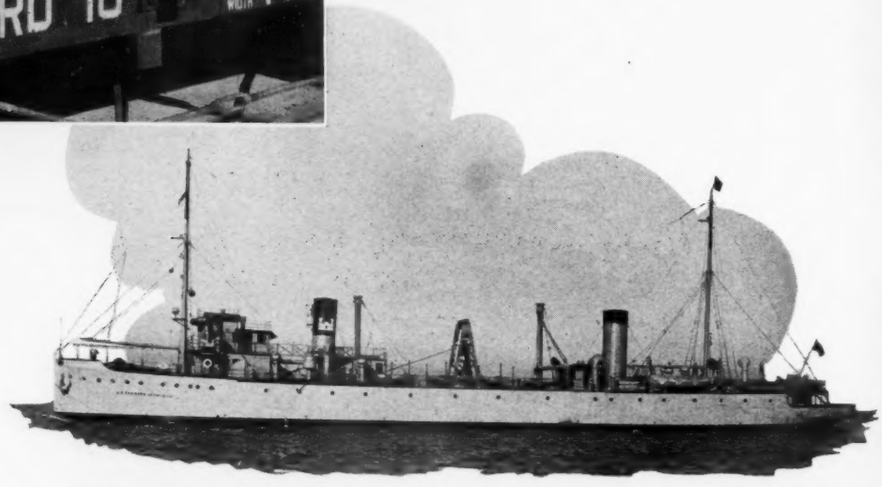
These dredges, that are familiar sights in harbors and rivers, are the landscapers of our waterfronts. They command little attention because the observer sees only the wooden hulls with their surmounting derricks. Few ever get a glimpse of the cutter blades that dislodge the submerged material, or of the great lengths of submerged pipe line that transport sand, mud, and crushed rock at high speed to areas of deposition.

The removal of Dead Man's Island at the entrance to Los Angeles Harbor was a landscaping as well as an engineering job. This small mountain, which was 95 feet high and projected 60 feet above the water, was eaten away by dredges, moved a considerable distance, and converted into a strip of land 2,800 feet long and 1,000 feet wide to serve as a Government military reservation. This interesting work involved the transfer of 2,000,000 cubic yards of earth, and required two years to complete. The dredges, anchored in the bay, attacked the island beneath the water surface, undermining it and causing it to topple, piecemeal, into the bay. Rocky portions, including single pieces weighing up to 12 tons, were carried away by barges and used to build a 32-foot-high seawall to retain the new land which was pumped in behind this barrier. Although the undertaking deprived Los Angeles of an important landmark which has been immortalized in Richard Dana's *Two Years Before the Mast*, its harbor was relieved of a dangerous obstruction. Removal of the island permitted widening the channel to 1,000 feet.

Several years ago the Santa Fe Railroad purchased a tract of land at Richmond, Calif., which was practically worthless because most of it was underwater at high tide. A dredging program created a channel half a mile long, 300 feet wide, and 35 feet deep, that was navigable by large ships; and the excavated material helped to reclaim 250 acres of marginal land

MARINE VACUUM SWEEPER

As a means of clearing harbor entrances of dangerous sand bars and of keeping fairways open, the Government has developed and maintains a fleet of hopper dredges of the type shown below. These are seagoing vessels, designed to transport the material out into deep water for dumping. The dredged sand is sucked up through a pipe line which is hinged at the upper end to permit it to extend downward at any angle desired. At the lower end of the pipe is a huge metal shoe which works on the principle of the vacuum sweeper. With such equipment it is possible to dredge to depths of 40 and 50 feet. The view at the left shows a shoe weighing 6 tons.



for industrial use. With both water and rail transportation close at hand, that land became extremely valuable.

From a purely landscaping standpoint, one of the most spectacular dredging jobs was that done at Long Beach, Calif. That city wanted to erect a $3,000,000 auditorium on a bay site that was submerged. Instead of lawns, shrubbery, and roadways as its setting, it was proposed to utilize the surrounding water, and to enhance its beauty at night by using colored lights for illumination. A "piece of land" sufficient for the purpose was dredged from the sea, annexed to the mainland, and the auditorium reared upon it. A rock-filled semicircular pier was constructed around the building and out into deep water. Thus was evolved something new in landscaping—an expanse of sea on all but one side of the structure.

Modern high-pressure dredging makes it possible to move sea-bottom material four or five miles inland to convert marshland into solid ground and to make it fit for varied uses. By means of pontoon pipes, with ball-and-socket connections to provide flexibility, and booster pumps even greater distances can be negotiated. In the construction of the Lindbergh Field at San Diego, material was brought in from three miles out at sea, and similar stretches were involved in filling in lowlands in Los Angeles with sediment obtained incidental to harbor dredging. During dredging operations at Pearl Harbor, Honolulu, pipes were laid for 20,000 feet through sugar plantations, where leakage would have endangered the crops—yet no damage was done.

A modern suction dredge houses up to 4,000 hp. of electrical energy which is generated aboard, usually with diesel-engine power. The crew may number 50 or more men, all skilled mechanics as well as seasoned sailors. The most important duties fall to the leverman who, from his control room at the forward end, keeps a watchful eye upon the swinging of the ladder bearing the cutting blades; notes the tide gauge at frequent intervals; and observes the behavior of the driving machinery and the condition of the floating pipe line. A break anywhere in the discharge line is at once indicated on the pressure gauge, and a valve is set to prevent any possibility of a back flow.

A single large dredge may deliver as much as 30,000 to 40,000 gpm. of water and mud through the pipe line. The cutter, which is keyed to the end of the swinging ladder, sometimes has a diameter of as much as 7 feet. It is made of manganese steel; and, turned at the rate of 25 rpm. by a 1,000-hp. motor, it grinds and crushes soft rock, sticks, and other materials commonly encountered on ocean and river bottoms. The pump which provides both the suction to draw the materials through the pipe line along the ladder and the pressure to force it out through the great length of delivery line sometimes measures 11 feet in outside diameter. The casing weighs up to 10 tons and is made up of 5-inch-thick steel walls to give it the strength to withstand the constant battering it receives from earth, rocks, etc.

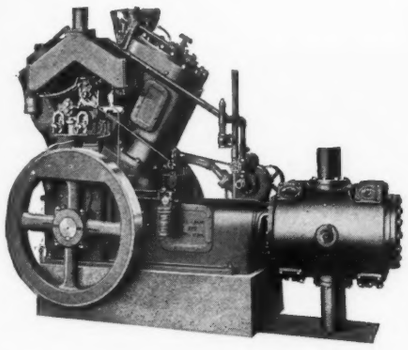
Where the delivery line is carried on the surface of the water, it is supported directly by pontoons. When it is necessary to submerge the pipe in order to leave fairways open for navigation, it is suspended from the pontoons by means of slings of suitable length. The weight of the pipe and the material it carries is sufficient to cause it to sink. When it is desired to bring the line to the surface, it is emptied by pumping it out with compressed air, whereupon its buoyancy increases and it rises at once. Where discharge lines leave the water and are run overland, they frequently reach considerable elevations. Under such circumstances booster pumps are sometimes installed to meet the increased head. In Astoria, Ore., a street more than 30 feet higher than the low-water level of the Columbia River was surfaced with sand that was delivered through 6,000 feet of piping, of which 1,500 feet was submerged to a depth of 70 feet.

To meet the conditions of a service that calls for the dumping of excavated material considerable distances out at sea, the U. S. Government has developed what are known as hopper dredges. These craft are from 200 to 300 feet long, and have in their holds hoppers of 2,000 to 3,000 cubic yards capacity. This type of dredge does its work as it plows along at slow speed in keeping shipping lanes open. The suction pipe, hinged at the pump, extends downward 40 feet or more; and at its lower end is a 6-ton shoe which drags the bottom and picks up whatever is within its reach with much the same action that a vacuum sweeper exerts in cleaning a carpet. The dredged material is delivered to the hoppers, and the excess water drains off by flowing over the sides. When the hoppers are filled, the dredge moves off to deep water and dumps their contents through gates in the bottom of its hull.

Seagoing hoppers of this type are utilized extensively for reclaiming sand from river bottoms, and about 30 per cent of the sand used for building purposes is now obtained in this manner. One large firm operates a fleet of these dredges on the Great Lakes.

NEW GAS-ENGINE-DRIVEN COMPRESSOR HAS NOTABLE FEATURES

A NEW design of gas-engine-driven compressor for handling either air or gas has been recently placed on the market by Ingersoll-Rand Company, 11 Broadway, New York City. It is designated the Type XVG. The smallest unit of this class consists of a vertical, 2-cylinder, 4-cycle, V-type gas engine driving a



standard, horizontal I-R compressing cylinder. Larger sizes are made up by assembling two, three, or four sets of these power and compressing cylinders side by side, using one crankshaft and crankcase and one flywheel. Such an arrangement is not only economical but it also meets the various requirements that make for maximum efficiency. It permits the use of small power cylinders, thereby avoiding excessive temperature differences and simplifying cooling problems.

The construction makes for excellently balanced, smooth-running machines. Weights are so moderate that units can be shipped from the factory completely assembled. This light weight, together with small foundation and buidling requirements as well as ease of handling, lessens the cost of installation. Light, strong reciprocating parts, large bearings, low piston speeds, and conservative ratings insure low maintenance costs and long service life.

The XVG is built in sizes of 60, 125, 190, and 260 hp., and these have two, four, six, and eight power cylinders, respectively. There is one compressing cylinder for each two power cylinders. These units are designed primarily for service in oil and gas fields, but are suitable for industrial use wherever gas is available as power.

If you are a tree lover and have some fine specimens standing in front of your home, you will be interested to learn that the General Electric Company has improved its tree wire which is used in residential districts that do not justify the installation of underground cables. This wire is available for service up to 8,000 volts; is insulated with rubber; and is protected first with a waterproof covering and then with a weatherproof cotton braid. It may be strung through trees without damaging them or their foliage; and, conversely, there is not much danger of swaying branches abrading the wire and causing leakage or short circuits.

FAULTY LOADING SHORTENS LIVES OF CONVEYOR BELTS

PROBABLY 30 per cent of the conveyor belts in operation are prematurely destroyed because of faulty loading conditions that are avoidable, according to *Mechanical Handling*.

To begin with, it is pointed out, the load should be applied at an even rate and at a speed equal to that of the belt. It is furthermore recommended that the hoppers, where possible, be two-thirds as wide as the belt and provided at the sides with skirt boards. Loading should be done carefully so that the contents of the hoppers will fall on the belt at a point midway between two of the carrying idlers. If the weight comes on the idlers, and the drop, besides, is unnecessarily high, serious damage may result. While the injury may amount to no more than a bruise at the time, it is a weak spot in the cotton fabric that will soon give way under repeated impacts. When handling coal or the like, it is a good idea to drill small holes in the loading hopper and chute so that the dust can fall through them on to the belt and thus form a cushion for the bulk material. If these precautions were more generally heeded, there would be fewer cases of "prematurely destroyed" conveyor belts.

ARMORED PITS USEFUL IN BREAKING UP SCRAP IRON AND STEEL

ARMORED pits, explosives, and electromagnets are the newest means introduced abroad for breaking up scrap steel and iron into furnace size for remelting. These facilities are said to be making short work of what normally is a troublesome job, and are in use at the Siemens-Martin Works of the Krupp cast-iron plant at Essen, Germany. The blasting pit is approximately 24 feet long, 18 feet wide, and 13 feet deep. It is lined with steel plates 1 foot thick and is provided with a cover, also made of 1-foot plate steel, weighing 83.3 tons. This cover is in three sections, in each of which there is a vent consisting of a circular opening and of a square plate supported by four stay bolts. This arrangement permits the explosive gases to escape—the protective plates keeping the flying pieces well within bounds.

The practice is to burn holes with oxygen torches into the over-size scrap and then to lower it into the pit by the electromagnet. There the holes are loaded with dynamite and tamped with sand, clay, metal chips or other suitable material. The depth of the holes and the amount of dynamite used depend, of course, upon the size and the weight of the mass. A 15-ton steel slab, for example, was shattered with 13.3 pounds of explosives packed in three holes, while 10 pounds sufficed in the case of an 11-ton roller. With oxygen at 2,200 pounds pressure, a hole 3 feet deep and from 1.2 to 1.4 inches in diameter can be burned in fifteen minutes. When ready for firing, the cover is put in place and the charges detonated by an electric blasting machine. With this done, the electromagnet again comes into play and clears the pit for the next load. This method of breaking up defective or scrap metal is said to cost less than skull cracking or gas cutting, now commonly employed for this work.

Courtesy, The Explosives Engineer

ARMORED BLASTING PIT

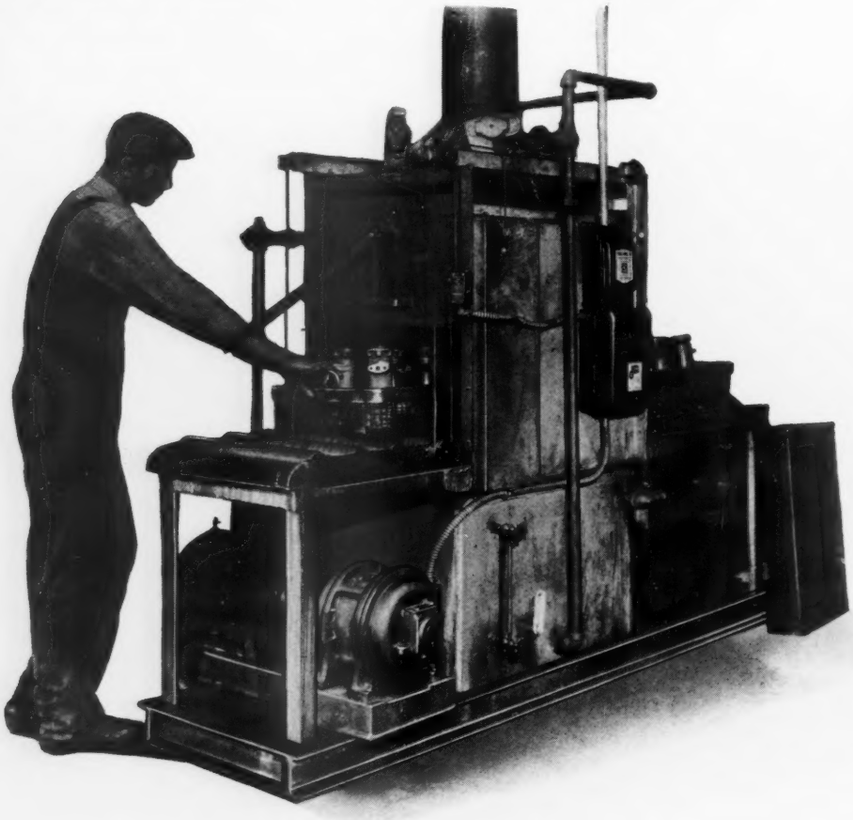
in which massive piecs of scrapiron and steel are safely and quickly broken up for remelting. Each of the three cover plates, one of which is being lowered, is provided with a vent for the escape of explosive gases. The pit is a feature of one of the Krupp works at Essen, Germany.

RUSTPROOFING BITS OF METAL BY MACHINE

RUSTPROOFING compounds of different kinds have made their appearance since their value in protecting certain metals from the destructive action especially of moisture has been more generally recognized. Large structural shapes as well as small parts are now coated with one or the other of these substances so as to prevent their disintegration while awaiting use in storage either indoors or outdoors. Application is effected variously by brushing, air-spraying, and dipping, and latterly there has been developed equipment that expedites the treating of the hundred-and-one little odd-shaped pieces of metal that are required for manifold purposes. The machine is such that it can be easily attached to the apparatus that cleans or prepares the parts for the rustproofing operation.

The apparatus illustrated is the product of the Detroit Sheet Metal Works, and is said to handle pieces of intricate design as well as it does those representing flat surfaces to the liquid spray. The work is conveyed to the treating chamber in open-mesh baskets, which are placed on a roller loading table which is an integral part of the machine. Each basketload is pushed into the cabinet by hand, after which its doors are closed by depressing a hand lever. This also starts the flow of the rustproofing as well as of the compressed air, which serves to atomize the fluid and to make it go farther in every sense of the word.

As soon as the pieces have received their rustproof film, the operator again pushes the lever, thus shutting off the atomizer and opening the delivery and the discharge gates simultaneously. The next basketload, which has been made ready in the meantime, is now rolled in, taking the place of the finished work that it has pushed out of the cabinet, which is then once more closed. Air at from 40 to 80 pounds pressure per square inch is used, depending upon the viscosity of the rustproofing compound, and is generally taken from the main air line, if such be available. The capacity of the machine naturally varies with the product undergoing treatment, but it is not unusual to turn out basketloads 3 feet square at the rate of one every three minutes.



SAFEGUARDING AGAINST RUST

This air-spray machine is designed to handle small pieces of metal work of all kinds and to rustproof them in quantity. The parts are loaded in baskets, and as one is rolled into the cabinet by the operator it serves to push a finished basketload out through the opposite or discharge end, as illustrated.

SAFETY SHOTFIRING SYSTEM IN A COLLIERY

SAFETY-FIRST practices at the No. 1 Mine of the Spring Canyon Coal Company, Spring Canyon, Utah, include a system of shotfiring that seems to be about as foolproof as it could possibly be made. It is electrically controlled from an outside station located at the portal of the colliery; and not until all the men, including the shotfirers, are out of the workings can the charges be set off. The installation is described in detail by D. J. Parker, district engineer of the U. S. Bureau of Mines at Salt Lake City, Utah, in Information Circular 6675.

The blasting circuits are of No. 6 wire except in rooms where No. 14 is standard. In the firing circuit near the mouth of each entry is a switch which is locked when not in use. These are supplemented by three switches near the manway portal. Two of these are of the double-pole knife type and the third is a gate switch which is operated by a pipe gate at the portal. This gate is closed and locked after the shotfirers have done their work and left the mine. The closing of the knife switches completes the circuit between the colliery and the master firing control, which is of the time-limit variety. Each of the three switches has its own key, and each shotfirer carries one of them. This means that the blasting circuit cannot be completed until all three of the shotfirers are out of the mine and each has opened his particular switch. Connection is then established by means of the master control with the 200-volt, alternating-current supply line. An added feature of the system is that the current is cut off without delay after blasting—in fact, in considerably less than a second.

Permissible explosives and No. 6 detonators are standard at the No. 1 Mine. All holes are loaded and tamped by the shotfirers, who refuse to shoot holes which, in their opinion, are not properly placed. Wooden tamping bars and adobe stemming are used; and the charges are limited to the permissible 1½ pounds per hole. As a further safeguard, the detonators and explosives are carried underground separately in specially constructed rubberized canvas bags.

I-R ACQUIRES BLOWER BUSINESS

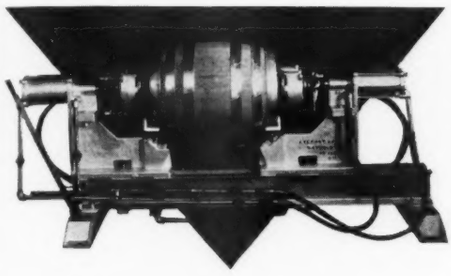
IT has been announced recently by Ingersoll-Rand Company that it has acquired the General Electric turbo-blower business and the exclusive rights to the use of that company's patents. Ingersoll-Rand is a long-established manufacturer of blowers of medium and large capacities for pressures ranging up to 100 pounds, and General Electric has specialized in both single- and multi-stage units for a variety of low- and medium-pressure services. Through the consolidation of these two departments, Ingersoll-Rand is in a position to meet the broadest possible demands for blowers and for centrifugal-type compressors.

The line of low-pressure blowers now offered by Ingersoll-Rand includes units for aerating sewage, for ventilating and air-conditioning systems, for blowing cupolas, for atomizing oil in furnaces, for furnishing agitating air in flotation work, as well as for raw-water-ice systems, for operating pneumatic conveyors, and for inducing vacuums and pressures in handling manufactured gas. The medium-pressure machines cover the entire gas-booster and blast-furnace and converter-blowing fields.

The manufacturing equipment of the General Electric Company is being moved to Ingersoll-Rand's Phillipsburg, N. J., plant where all types and sizes of turbo-blowers are to be manufactured. The sales activities will be directed from the latter's general offices at 11 Broadway, New York City.

BRANDING BEER KEGS WITH AIR UNDER PRESSURE

WITH the return of beer in the United States, manufacturers of brewery equipment have had to sit up late nights, figuratively speaking, to bring it up to date so that it would meet the present-day standards imposed by industry generally. In this they have not fallen short; and the hundreds of breweries the country over that have again opened their doors after years of inactivity are probably as



modern and efficient in their operation as plants engaged in other branches of work that have not been so handicapped.

Everything, from the large machines on down to the lesser equipment, has been and is being modernized; and compressed air that did not play much of a part in the brewery in the days before prohibition is now helping to speed up production. Pneumatic conveyors are installed to handle bulk material; bottles are filled as well as washed with the assistance of compressed air; and kegs are branded with air under pressure.

It is to the interest of breweries to mark their barrels and kegs for identification so that they can be reasonably sure that they will be returned to them when empty. This is done by branding, and the machines now generally used for this purpose are automatic in their action. Our illustration shows a brander of the Everhot type, which is designed to mark both ends of a keg simultaneously. It can be adjusted in less than a minute to take kegs of any length and circumference by loosening a nut, sliding half of the frame on its bed, raising or lowering the keg standards, and putting a wedge in place.

Each of the two branding elements, between which the kegs are set one after another, consists of a die, a heater immediately behind it, and an air cylinder. The die is made of a special alloy that resists corrosion, and the legend on it is cut deep to insure a good impression even on an uneven surface. The burner is heated up quickly by an admixture of air and gas, and gives the die a high and uniform temperature at all times. Compressed air at a pressure of 35 pounds is applied to the cylinders, which bring the dies in contact with the wood under an impact of 600 pounds. Branding is the work of but a few seconds, and the resulting identification marks are deep and lasting.

The Everhot Manufacturing Company also makes a post-mounted brander that can be adjusted to the height of any barrel or case. This manually operated fixture is likewise air-and-gas heated.

HANDLING SHEET STEEL BY AID OF VACUUM CUPS

VACUUM cups are serving a very useful purpose in stamping plants where much steel in sheet form has to be handled. These sheets are stacked in piles; and it takes practice to lift up the top sheet and to separate it from the one immediately beneath.

Of the many schemes that have been devised to assist in this operation, vacuum cups have apparently proved to be most satisfactory. While they may differ in the method of mounting, the general result is the same. One of the handiest arrangements is that of a small rubber vacuum cup used for lifting sheets of light weight. This cup normally hangs over one corner of the pile, and is suspended by a long spring attached to a short handle on the cup that makes it look not unlike a dinner bell. By means of this the operator can quickly raise one corner of the uppermost sheet, thus permitting him to get a firm grasp on it with his disengaged hand. He can then let go of the vacuum cup and with both hands pass the sheet over to the press.

VACUUM AND COMPRESSED AIR FROM ONE MACHINE

AIR compressors are sometimes operated in reverse to induce a vacuum; but for a compressor to create a vacuum and to supply air at one and the same time smacks of the nature of a feat. While not recommended as good practice it can be done; and this was demonstrated in a plant in which is installed a 2-stage unit that furnishes air to start a gas engine.

This plant was in need of a vacuum for a new process of manufacture. There was no vacuum pump available, so the engineer used the compressor instead and connected a suction line to the intake of the low-pressure cylinder. So far so good. But what happened when low-pressure air was required as well for blowing? The engineer simply employed both of the machine's cylinders single stage by removing the safety valve between the two stages. In this way he made the high-pressure cylinder supply the low-pressure air for the engine while the low-pressure cylinder continued to maintain the vacuum.

ABRASIVE BLAST REVEALS SECRETS OF STRUCTURAL MATERIALS

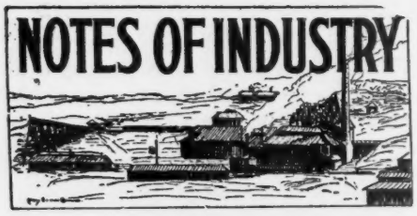
TESTING structural materials of all kinds in advance of application, so as to determine how they will stand up under service conditions, is today common practice. These tests cover a wide range, and have led to the development of laboratory equipment that has reduced the work to a science and, for the most part, permits it to be done quickly and at comparatively low cost.

Among the newest of these devices that have made their appearance is the MacLeod abrasive blast, a compact machine that was designed primarily for testing the wearing quality of building and paving stone, concrete, tile, brick, clay, and similar materials, but that can be used with equal facility to determine something about the inside history of metals.

In the machine, test pieces can be subjected to the attack of different grades and kinds of abrasives such as sand and carborundum or steel grit. The samples, *A*, are in the form of cubes, 3 inches square, and are clamped, one at a time, over a 2½-inch-diameter aperture between the main body of the machine and a small circular chamber, *E*, on top of it. This is done by means of the clamping head *B*, the crank *D*, and the clamp lifter *C*. In this position, the full force of the blast from the nozzle, which is directly beneath the opening, is directed against the test piece. The discharged abrasive drops back into the hopper in the base of the machine and is used so long as it retains its sharp cutting edges. Little dust is created except when sand is employed, and then it is advisable to attach a fan and a collector to the exhaust pipe, as illustrated.

Stone varies widely in texture. This is revealed by the extremely hard abrasive particles which break away all the material that cannot resist their attack—bring to light all inherent weaknesses. The samples, after they have been acted upon, therefore give dependable information on stratification, distribution of soft and hard layers, occlusions, pores and cracks, differences in the size of grains, etc. In the case of paving or other materials that are subjected to much wear and tear, the abrasive-blast method of testing has proved exceptionally advantageous because it shows whether or not they are uniformly of the high grade demanded for that service. The machine also makes it possible to compare different kinds of stone, concrete, etc., for which purpose the test conditions must be alike in every particular.

NOTES OF INDUSTRY



In operating its fleet of airplanes, the United States Air Lines are said to require annually 8,000,000 gallons of gasoline and 330,000 gallons of lubricating oil.

A diesel engine has been designed and built in Germany that burns an admixture of hydrogen and oxygen. Concurrently has been developed a process for the production of low-cost hydrogen. The unit is said to be performing satisfactorily, and at a considerable reduction in operating cost as compared with an engine of like capacity using gasoline or heavy oil.

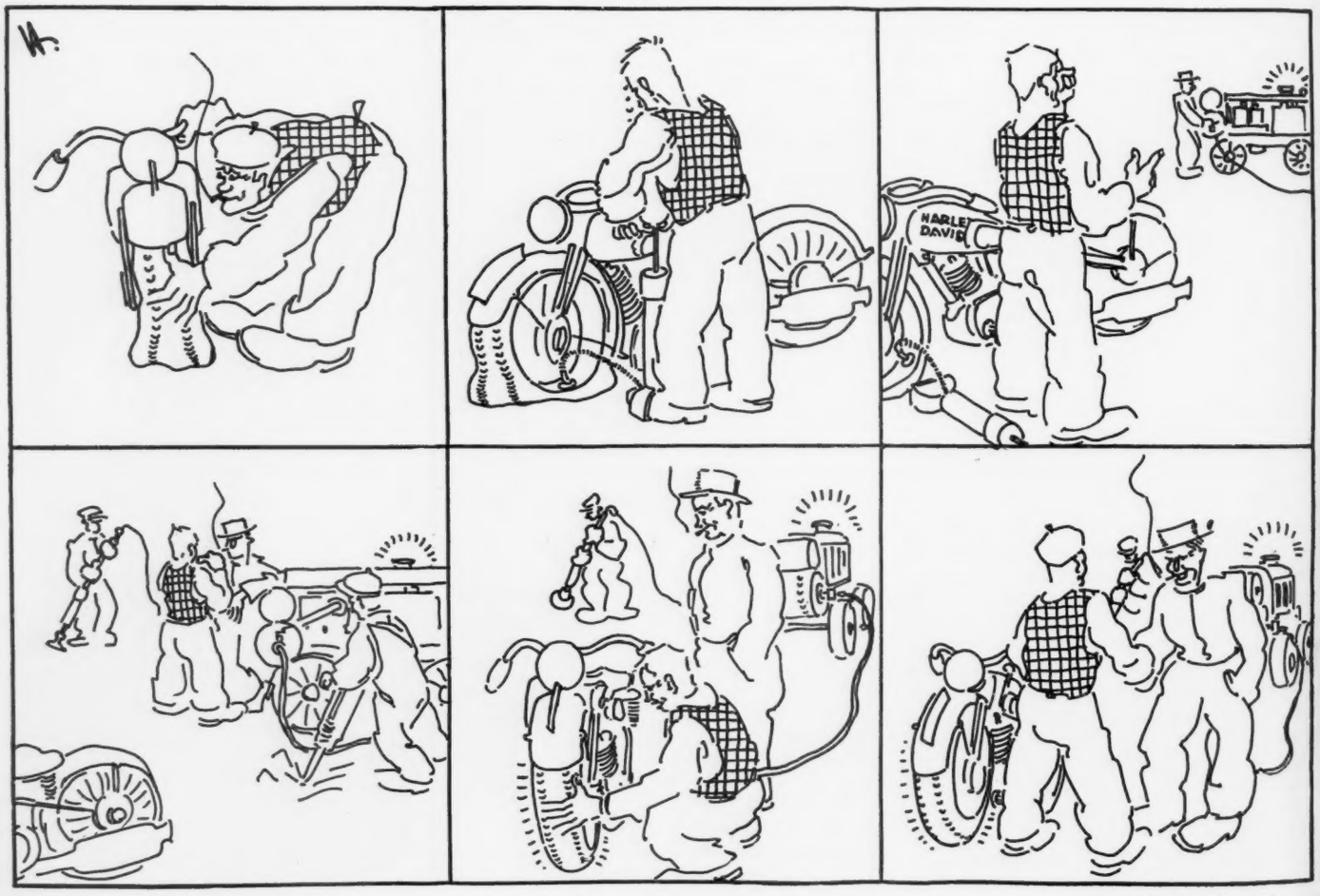
Gas with a "bouquet" is being offered the customers of the Amarillo Gas Company to facilitate the detection of leaky pipes around the house, industrial plant, etc. Approximately 15 gallons of vaporized "Calodorant," a volatile oil product, is being added to the gas distributed daily. This gives the fuel a penetrating but not unpleasant odor and does not affect its heating value.

Long-distance teletype service for the convenience of the public has been put in operation between Hamburg and Berlin by the German post office, which also controls the Reich's telephone and telegraph systems. If financially successful, the plan is to link up all the principal German cities in this way and to make connections with foreign countries equipped with this means of intercommunication. This puts within reach of the man with a small business a service that has been enjoyed for sometime by the government and large concerns. The advantage of the teletype is that written messages can be received in an office even when it is closed.

Portable Compressors, Tools, and Equipment is the title of a new catalogue issued by Ingersoll-Rand Company, New York. It describes and illustrates a wide range of machines and tools which have many applications, and lists the type of work for which each unit is particularly fitted. The company's newest products—such as the 2-stage air-cooled portable compressor, the air-cooled stationary "Motor-compressor", and "Jackbits"—are covered, as well as its complete line of drills, paving breakers, pile drivers, drill-steel sharpeners, oil furnaces, pneumatic tools, hoists, and boring machines. A number of pages are also devoted to stationary compressors, diesel engines, aftercoolers, air receivers, etc. The catalogue, Form 1604E, can be obtained free from any Ingersoll-Rand office. It is designed to assist all users of compressed air.

At Koblenz, the German Government is erecting a 624-foot radio tower, the highest ever attempted. American Southern pine is being used throughout, and is being assembled by means of disk, plate, and ring connectors which are inserted between members to be joined and made fast with bolts. By thus distributing the load, it is said that the strength of the joints is increased from four to eight times as compared with conventional construction methods. More than 50 wooden towers, using this new method of assembly, have been erected in Europe in recent years. The departments of Commerce and Agriculture earlier this year issued a handbook ***Modern Connectors for Timber Construction,*** which describes this new method and its application to the building of such structures as bridges, docks, and warehouses under American conditions.

Story Without Words



Drawn by Hans Kominek